University of Southampton

University of Southampton Research Repository

Copyright © and Moral Rights for this thesis and, where applicable, any accompanying data are retained by the author and/or other copyright owners. A copy can be downloaded for personal non-commercial research or study, without prior permission or charge. This thesis and the accompanying data cannot be reproduced or quoted extensively from without first obtaining permission in writing from the copyright holder/s. The content of the thesis and accompanying research data (where applicable) must not be changed in any way or sold commercially in any format or medium without the formal permission of the copyright holder/s.

When referring to this thesis and any accompanying data, full bibliographic details must be given, e.g.

Thesis: Author (Year of Submission) "Full thesis title", University of Southampton, name of the University Faculty or School or Department, PhD Thesis, pagination.

Data: Author (Year) Title. URI [dataset]

University of Southampton

Faculty of Social Science

Southampton Business School

Understanding Project Managers' Behaviour when using Artificial Intelligence for Project Control

DOI (via Pure) https://doi.org/10.5258/SOTON/D3347

By

Fredrik Kockum

ORCID ID: 0000-0002-2546-4659

Doctor of Philosophy

May 2025

University of Southampton

Abstract

Faculty of Social Sciences

Southampton Business School

Doctor of Philosophy

Understanding Project Managers' Behaviour when using Artificial Intelligence for Project Control

by

Fredrik Kockum

This research thesis contributes to Project Management (PM) literature and project managers' behaviour when using AI-based control analysis. The research premise is based on project managers using AI analysis as an early warning system for project control and studying their behaviour and decision-making when experiencing project escalation. For this purpose, the thesis adopts the theoretical framework of Behavioural Decision Theory, specifically the lens of Descriptive Decision Theory and the established concept of ”heuristics and biases”. Research on project managers’ behaviour during project control is well-established through the phenomenon of Escalation of Commitment(EoC). The main research question is answered through empirical research papers and is based on interviews with 22 individual project managers as research participants having experience using AI for project control analysis. The thesis contributes to synthesising the literature on AI in PM through a Systematic Literature Review and suggests two behavioural constructs “The Wait Effect” explaining EoC behaviour when using AI and “Override AI bias” explaining de-escalating behaviour. Further contributions include the variables influencing these constructs: “project uniqueness”, “explainable AI”, “dynamic project data”, and “information asymmetry”. The thesis further suggests the variable “trust in AI” can decrease biases on the use of AI for project control.

Table of Contents

Abstract 2

Table of Contents 3

Table of Tables 6

Table of Figures 7

List of Accompanying Materials 8

Research Thesis: Declaration of Authorship 9

Acknowledgements 10

Definitions and Abbreviations 11

Chapter 1 Introduction 12

1.1 Research Background and Context 12

1.2 Project Management 14

1.3 Project Management and Operational Research 19

1.4 Project Management and Artificial Intelligence 20

1.5 Research Gap and Scope 23

1.6 Research Aim 24

1.7 Introduction Summary 27

Chapter 2 Theoretical Framework 28

2.1 Project Control 28

2.2 Analytical AI 31

2.3 Decision Theory 32

2.4 Behavioural Decision Theory 33

2.5 Behavioural Operational Research 37

2.6 Summary of Thesis Chapters and Theoretical Framework 40

Chapter 3 Research Methodology 42

3.1 Interpretivist Research Philosophy 42

3.2 Abductive Research Approach 45

3.3 Grounded Theory Research Strategy....46

3.4 Research Ethics....54

3.5 Summary of Research Methods....55

Chapter 4 First Research Paper....56

Title: Mapping the Literature of Project Management and Artificial Intelligence: A Systematic Literature Review....56

Abstract....56

4.1 Introduction....56

4.2 Theoretical Background....58

4.3 Methodology....59

4.4 Review Findings....62

4.5 Discussion....69

4.6 Conclusion....72

Chapter 5 Second Research Paper....74

Title: The Impact of Artificial Intelligence on Project Managers' Behaviour: An Exploratory Study....74

Abstract....74

5.1 Introduction....74

5.2 Literature Review....76

5.3 Trust in AI Technology....81

5.4 Behavioural OR and Project Management....83

5.5 Research Methodology....86

5.6 Results....98

5.7 Discussion....102

5.8 Future Research and Limitations....105

5.9 Conclusion....105

Chapter 6 Third Research Paper....107

Title: Exploring Project Managers' Heuristics: Mitigating De-Escalation Biases during Artificial Intelligence Analysis 107

Abstract 107

6.1 Introduction 107

6.2 Literature Review 109

6.3 Research Method 116

6.4 Results 123

6.5 Discussion 125

6.6 Implications for Practice 128

6.7 Limitations and Future Research 129

6.8 Conclusion 129

Chapter 7 Thesis Discussion 131

7.1 Systematic Literature Review Discussion 132

7.2 Empirical Research Contributions 133

7.3 Mitigate Bias Behaviour Through Trust in AI 136

7.4 Theoretical Model of AI in Project Management 137

7.5 Agenda for the Project Community Implementing AI 138

Chapter 8 Thesis Conclusion 144

8.1 Theoretical Contribution to Knowledge 144

8.2 Implications for Practice 145

8.3 Limitations and Recommendations 146

8.4 Future of AI in Project Management 148

Appendix A Articles Included in SLR 150

Appendix B Research Ethics Form: 53466 153

Appendix C Interview Data 156

List of References 377

Table of Tables

Table 1: Research Structure 25

Table 2: Categorisation of AI (Huang and Rust, 2018) 32

Table 3: Interview themes and semi-structured questions 49

Table 4: Interview participant demographics 50

Table 5: Conceptual Papers – Contemporary publications 63

Table 6: Individual AI Model Papers – Contemporary publications 64

Table 7: Hybrid AI Model Papers – Contemporary publications 65

Table 8: Empirical Papers – Contemporary publications 67

Table 9: Identified methodological themes in SLR 68

Table 10: Identified project industries in SLR 68

Table 11: Identified knowledge areas optimised by AI in SLR 69

Table 12: Literature of optimising project control through AI 80

Table 13: Literature on management decision-making and AI 81

Table 14: Project Managers' Bias Behavioural Constructs adapted by Wang et al. (2020b) 83

Table 15: Coding process for the wait effect causal loop diagram 87

Table 16: Summary of all feedback loops of the wait effect CLD 101

Table 17: Coding process for override AI causal loop diagram 117

Table 18: Summary of all feedback loops of override AI bias CLD 125

Table 19: Final 63 articles included in SLR 150

Table 20: Interview data summary 156

Table of Figures

Figure 1: Adapted project life cycle (van den Ende and van Marrewijk, 2014) 16

Figure 2: Simplified project life cycle adopted by this thesis 17

Figure 3: Thesis hierarchy of DSSs, OR Tools and AI-based project tools 23

Figure 4: Iron Triangle (Lock, 2014) 28

Figure 5: High level theoretical framework and relationship of key research areas 41

Figure 6: Research Methodology 42

Figure 7: Causal link of “project data generation” and “trust in AI model” 53

Figure 8: Causal links of “project data generation”, “trust in AI model”, and “willingness to take corrective action” 53

Figure 9: Causal links of “project data generation”, “trust in AI model”, “willingness to take corrective action”, and “rework discovery” 54

Figure 10. Search protocol 62

Figure 11: Feedback loops “B1 - Work Completion”, “B2 - Rework Completion”, “R1 - Rework Cycle” 99

Figure 12: Added feedback loops: “R2 - AI Data Generation”, “R3 - Trust in AI” 100

Figure 13: Added feedback loops: “R5 - Anchoring to Data”, “R6 - The Wait Effect” 101

Figure 14: Reinforcing and Balancing loops of Project Escalation 115

Figure 15: Reinforcing Loop 1: Override AI Bias 124

Figure 16: Reinforcing Loop 2: Escalation of Commitment 125

Figure 17: The Weighing Scale of Project Managers’ Heuristics and Biases with Explainable AI 138

List of Accompanying Materials

The thesis research is based on the following data files:

- Search process for systematic literature review in excel
- Qualitative data coding process in excel

After final submission the above material will be available here:

https://doi.org/10.5258/SOTON/D3347

Research Thesis: Declaration of Authorship

Print name: Fredrik Kockum

Title of thesis: Understanding Project Managers' Behaviour when using Artificial Intelligence for Project Control

I declare that this thesis and the work presented in it are my own and has been generated by me as the result of my own original research.

I confirm that:

1. This work was done wholly or mainly while in candidature for a research degree at this University;
2. Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated;
3. Where I have consulted the published work of others, this is always clearly attributed;
4. Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work;
5. I have acknowledged all main sources of help;
6. Where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself;
7. None of this work has been published before submission

Signature: ..... Date:.....

Acknowledgements

I enjoy writing this section due to it allows me to reflect and soon submit my PhD. I thank my PhD supervisors Dr Nicholas Dacre and Professor Martin Kunc for supporting my PhD journey. It has been exciting to challenge myself with higher academic thinking and analysis on a topic that will be highly current for many years ahead. I also want to thank Dr Serkan Ceylan, who influenced my interest in project management during my master's and was key to my decision to enter the PhD programme at the University of Southampton.

Through my PhD journey I have experienced more ups and downs than I could have imagined before entering this PhD programme. I share the experience with other PhD candidates to conduct research during the Covid-19 and lockdowns. After moving home and continuing my PhD from Sweden, I had a 12 months break from my PhD during 2023, which gave me new perspectives. I re-entered the PhD programme in January 2024 and am now happy and proud of my decision to complete my PhD. Again, I appreciate the support from my supervisors and my family and friends in Sweden and abroad.

I appreciate that I have become deeply knowledgeable in my research topic, but more importantly I have learnt a lot about myself. However, I am humble about the fact that one cannot know everything, and I strive for continuous learning. I have grown from situations where my analysis skills have been challenged by my peers, and I have learned that perseverance will outrun almost every challenge. Lastly, I am grateful for this opportunity and will not take this experience for granted.

Definitions and Abbreviations

AI ..... Artificial Intelligence

BOR ..... Behavioural Operational Research

CLD ..... Causal Loop Diagram

DoC ..... De-Escalation of Commitment

DSS ..... Decision Support System

EoC ..... Escalation of Commitment

EVM ..... Earned Value Management

FF ..... Fast and Frugal

HB ..... Heuristics and Biases

OR ..... Operational Research

PM ..... Project Management

Chapter 1 Introduction

1.1 Research Background and Context

The motivation for conducting a PhD research on the area of Project Management (PM) and Artificial Intelligence (AI) is based on several aspects. 1) The main motivation is to explore the evolving and fast-changing area of AI and to understand the implications on the field of PM. The fast changes in this area are in many ways positive forces and bring attention to how AI can assist managers and business in their daily work. On the other hand, these changes may also have negative implications on the PM profession. Since year 2020, AI technology is evolving at an unprecedented pace through analytical and generative AI, transforming various industries and reshaping the landscape of PM. Managers and organisations are increasingly adopting project-based structures, making it critical to understand how AI applications can be implemented and their potential impacts.

2) A second motivation is AI's integration into project management offers numerous benefits, including enhanced decision-making, improved efficiency, and optimized resource management. AI tools can provide highly advanced analysis, thereby increasing project success rates. However, the rapid adoption of AI also presents challenges, such as the need for understanding decision-making processes and the impact on managers' behaviour.

3) A third motivation is the evolving AI landscape impacts the PM profession by focusing on enhancing the human project manager. It is critical for managers and organisations to stay at the forefront of technological advancements to leverage AI effectively and achieve project success. As AI continues to evolve, its role in PM is likely to become increasingly significant, shaping the future of the project profession.

To meet business objectives in today's fast-paced business world, managing temporary teams and projects through PM methods is a common management approach. In the UK alone, 51% of businesses predict growth in project-based activities (APM, 2024). PM theories differentiate from "business-as-usual" and require specific knowledge to achieve the set business objectives (Turner and Müller, 2003). Unfortunately, too many projects do not achieve the objectives according to plan and the project manager faces challenging and complex situations where their decision-making is crucial for the success of the project (Pinto et al., 2022). To ensure project success, it is critical to measure the project's progress through control activities. The main activities during the control process involve planning, measuring, monitoring, and taking corrective action (Rozenes et al., 2006). It can also be formulated as setting baselined

standards, measuring the actual project progress against the baselined plan, and responding to early warning signs of project escalation by taking corrective actions (Olawale and Sun, 2013). To assist project managers with these activities, Operational Research (OR) has influenced the field of PM through optimisation modelling and mathematical techniques (Tavares, 2002, Kanakaris et al., 2019). The field of OR has made a substantial impact on the PM areas of project control, planning, and scheduling (Hazır, 2015, Kanakaris et al., 2019, Ormerod, 2020b, Pellerin and Perrier, 2019). This includes project control techniques to measure progress and simulate project outcomes through Decision Support Systems (DSSs) (Acebes et al., 2014, Hazır, 2015, Rozenes et al., 2006). To further optimise project areas, researchers demonstrate potential in support techniques based on AI technology (Cubric, 2020, Ormerod, 2020a).

Since the 1950s, AI has been discussed and hyped for the potential good it can provide for humanity in terms of improving efficiency and assisting in complex problem-solving through improved analytical ability (Davenport and Ronanki, 2018). However, risks with AI have also raised concerns regarding the consequences of workers being replaced by autonomous machines and reduced personal integrity. Further implication of AI is that it will bring one of the largest transformational changes humanity has ever seen (Kolbjørnsrud et al., 2016). This transformational change is suggested to take shape in both positive and negative ways, and is likely to impact project managers' daily work and how businesses run projects.

The fields of OR and AI in PM have been studied for a significant time, however, it is only in the recent decade that research on AI in PM has seen noticeable publications. Considering the suggestion of AI's transformational change, it is argued that AI will impact PM and how projects are managed. Building on this argument, research in project control shows great potential when utilising AI to improve project control techniques and the ability to assist project managers' complex decision-making (Pellerin and Perrier, 2019, Hazır, 2015).

To understand managers' decision-making, this thesis adopts Descriptive Decision Theory. In this field, heuristics and biases are central concepts, and it is suggested that managers tend to suffer from biased decision-making (Gigerenzer et al., 1999, Kahneman and Tversky, 1979). Kahneman has been a major influence in the fields of PM and decision-making (Cantarelli, 2025). Further on, researchers suggest project managers have cognitive limitations in responding to early project warning signs (Haji-Kazemi et al., 2015). Further on, it is suggested that project managers suffer from biases during the control phase leading to warning signs being ignored (Benschop et al., 2020a, Compen et al., 2022). In summary, this thesis argues that the use of AI for project control is significant to study based on the following arguments: 1) PM methods have a central role in today's business environment and it becomes critically important to understand how PM is affected by AI, and 2) due to the transformational change of

AI technology, it becomes significant to study project managers' decision-making when using AI. The thesis suggests bringing significant contributions to the PM research community based on the research premise that AI technology has the potential to enhance project control techniques and assist in project managers' complex task to act upon early warning signs due to biased behaviour.

The following section 1.2 introduces the reader to the thesis' main topic of PM, project success, and the project life cycle. Further, PM is presented through the perspectives of OR in section 1.3 and AI in section 1.4. Additionally, the research gap and aim are presented with the research questions and objectives in sections 1.5 and 1.6.

1.2 Project Management

From the ancient Egyptian pyramids to modern space satellites, PM approaches have been used to achieve organisational and business objectives throughout history (Heagney, 2016). Modern PM theories originate from systems engineering and were first adopted by military operations during the Second World War (Lock, 2014). Today, using PM as a management approach is considered mandatory by businesses to survive in a competitive business market (Kerzner, 2017). The PM profession has developed from standard planning techniques, such as the Gantt chart and Critical Path Method to involve various methodologies, several international PM institutions, and university programs (Burke, 2013a). Even so, businesses believe that PM applications will increase (APM, 2024). Since more organisations apply PM practices to achieve business objectives and believe these approaches will increase, it is important to expand the understanding of this area through research (Gupta et al., 2019).

One of the advantages of PM practices and methods is the ability to adjust to a fast-changing environment by providing flexible production and cheaper products (Geraldi et al., 2011, Westland, 2007). There is a clear correlation between project success and applying PM success frameworks (Mir and Pinnington, 2014). However, it is stated that using PM methods does not guarantee project success, it rather increases the probability of success (Kerzner, 2017, Munns and Bjeirmi, 1996). PM methods are applied in multiple industries, such as construction, software engineering, knowledge-based projects, and event management (Walker, 2015). As a cross-industry management field, projects from different sectors can have similar definitions, methodologies, and techniques (Kerzner, 2022). The application across multiple industries is possible through the common project definition. While some project definitions are expressed differently, they share the same key foundations. Two definitions of projects are presented below:

"A project is a temporary organisation to which resources are assigned to undertake a unique, novel and transient endeavour managing the inherent uncertainty and need for integration in order to deliver beneficial objectives of change." (Turner and Muller, 2003, p.7)

"A project has a unique purpose… is temporary… is developed using progressive elaboration or in an iterative fashion… requires resources, often from various areas… should have primary customer or sponsor… involves uncertainty." (Schwalbe 2009, p. 5)

The two definitions have similarities while also complementing each other. The "temporary" characteristic entails a defined project start and end. The beginning and end of a project is explained through the project life cycle and demonstrates a project's development from conceptualisation to termination (Pinto, 2013). The "unique" perspective is significant for a project and is what differentiates a project from "business-as-usual" (Turner and Müller, 2003). An additional term that may define a project is "uncertainty" which is a central element in projects and critical during project decision-making (Daniel and Daniel, 2018, Stingl and Geraldi, 2017b). Other terms that Schwalbe (2009) uses to define projects are "iterative" which relates to agile methods, "resources from various areas" when specialist roles are gathered from different organisational departments, and "integration" when the project's output integrates with the organisation's business-as-usual operations (Heagney, 2016).

1.2.1 Project Management Success

It is suggested to distinguish between "project management success" and "project success". The former is defined as the short-term delivery of the project's outputs within time, cost and quality, and the latter refers to the medium- to long-term achievement of project outcomes and impacts (de Wit, 1988). This is aligned with other PM researchers (Badewi, 2016, Chih and Zwikael, 2015, Terlizzi et al., 2016). Further on, scholars suggest distinguishing the terms "project management success" as measuring the performance of the project manager achieving the project plan, "project ownership success" towards the project owner's ability to realise the business case, and "project investment success" to measure the sponsors' investment performance (Meredith and Zwikael, 2019). Different time perspectives characterise the mentioned definitions of success. The time perspective is a striking illustration in the case of Kodak's Instant Photo and its failure to adopt digital photos, leading to a commercial success one to two years after its completion. However, it was considered a business failure in the long-term based on failed project ownership success and investment performance (Griffin & Page, 1996). Another example is the Sydney Opera House, which was considered a short-term failure due to overruns. However, it became a long-term success by becoming an iconic landmark for the city of Sydney, bringing income through tourism and events.

It is stated that project success factors are not fixed throughout the project. Instead, success factors change as a project moves through the life cycle, and researchers suggest that different project tools are most effective in specific project phases (Ika and Pinto, 2022). For example, it is recommended to use a communication plan to achieve success during the initiation and control phase, whereas the Critical Path Method is crucial for the planning phase (Patanakul et al., 2010). Some academics suggest setting performance standards is part of the project initiation phase (Rolstadås et al., 2014). However, the thesis follows the suggestion of including setting performance standards within the control phase (Olawale and Sun, 2013). Chipulu et al. (2014) suggest summarising factors of success and failure through the concepts of "project control and extra-organisational goals" and "project team management/development and intra-organisational goals" with the indicators of "business goals", "project team", and "leadership and decision-making". Further on, it is suggested to set scope and performance standards in relation to the factors in the iron triangle (time, cost, and quality) with the additional elements of "project size", "duration", "postponement", and the manager's "formal decision mandate" (Sanchez et al., 2017). Moving on from PM success, the following sections expand on the project life cycle.

1.2.2 Project Phases and Life Cycle

A project is commonly divided into separate phases where each phase has unique characteristics based on the activities performed (Kerzner, 2022, Westland, 2007). Some argue that the life cycle consists of the four phases: "concept", "definition", "deployment", and "transition" (APM, 2019). Others suggest the five phases of "initiation", "planning", "control", "execution", and "closure" (Heagney, 2016). Further terms of phases are "conception", "feasibility", "implementation", "operation", and "termination" (van den Ende and van Marrewijk, 2014). This thesis combine the above terms with the activities of planning, scheduling, and control and defines project control as the phase after planning and scheduling activities related to the conception and feasibility phases, while before termination. Based on the project control definition to measure project progress by comparing the project plan with the actual project performance (Olawale and Sun, 2013), the thesis places the control phase alongside the implementation and operation phases, see Figure 1.

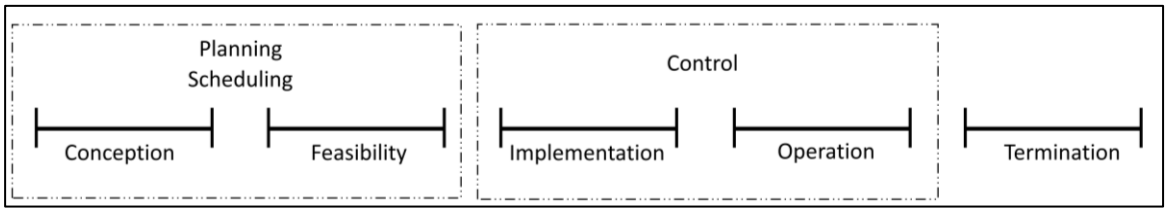

Figure 1: Adapted project life cycle (van den Ende and van Marrewijk, 2014)

Although there are different views regarding the life cycle phases, as demonstrated previously through the project definitions, projects share overall concepts and principles. Typically, every project goes through a "starting" phase where the project is initiated and planned to set the project's scope, concept and feasibility. This is followed by the control and execution phases, where the implementation, employment, and operation occur. The project finishes through a closure and termination phase. To simplify the phases, this thesis applies Figure 2 consisting of the phases: initiation, planning, control, and closure. The following sections present an overview of these phases.

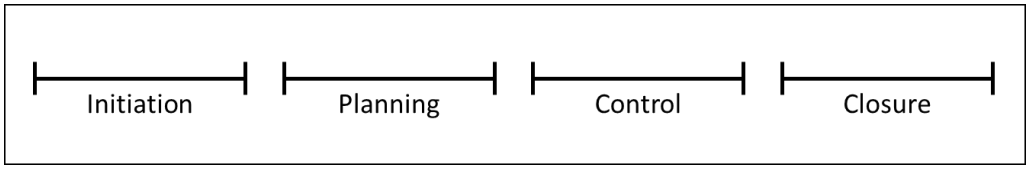

Figure 2: Simplified project life cycle adopted by this thesis

1.2.2.1 Project Initiation

This is a significant phase which has been studied for an extensive time (Morris, 1989). Some researchers argue that the initiation phase consists of 4 steps: search, preparation, bidding and negotiation. These steps are similar but not the same across all projects and can be transferable across industries which include a procurement process with bidding and negotiation activities (Savolainen et al., 2015). It is argued that initiation activities must be done correctly to set up the project for success (Söderberg, 2020). This is important due to success factors are suggested to be more critical in the early stages of the project and become more difficult to correct as the project progresses (Ojiako et al., 2023). This shows the significance of a project's early phase and that poor initiation practices will likely produce unseen errors that will cause ripple effects during later stages.

1.2.2.2 Project Planning

The focus of the thesis is the project control phase. However, the dependence between planning and control activities is significant. For example, one of the main activities during the control phase is measuring the actual project progress against the baselined plan (Olawale and Sun, 2013). Additionally, several researchers suggest that project control is predominantly combined with project planning and scheduling (Coelho and Vanhoucke, 2020, Demeulemeester and Herroelen, 2006, Hartmann and Briskorn, 2010, Hazır, 2015, Herroelen and Leus, 2005, Pellerin and Perrier, 2019, Pellerin et al., 2020, Vega-Velázquez et al., 2018). For example, the planning and scheduling techniques Critical Path Method and Program Evaluation and Review Technique (PERT) have enabled the development of project control tools

(Vanhoucke, 2012b). Planning and scheduling are studied to a far extent by researchers through the OR optimisation problem Resource Constraint Project Scheduling Problem (RCPSP) (Chen et al., 2012, Coelho and Vanhoucke, 2020, Hartmann and Briskorn, 2022, Hartmann and Briskorn, 2010, Pellerin et al., 2020, Vega-Velázquez et al., 2018, Wu et al., 2014). Project control activities are subject to planning and scheduling, and the dependency between planning and control is mutual (Vanhoucke, 2012a). Changes in the project plan affect controlling activities and vice versa. Hence, planning and control are not isolated phases but influence each other.

1.2.2.3 Project Control

The control phase is also referred to as the "execution" or "implementation" phase (Rozenes et al., 2006). The thesis defines the control phase according to the control activities by Olawale and Sun (2013): 1) Setting baselined standards, which sets the performance criteria and the indicators which the project will be measured on. 2) Measuring the actual project progress against the baselined plan. 3) Respond to early warning signs of project escalation by taking corrective actions. The premise of this thesis is to apply AI technology for control analysis, which has significant potential to improve DSSs (Gupta et al., 2021, Duan et al., 2019, Dwivedi et al., 2021, Haenlein and Kaplan, 2019, Hajiali et al., 2020, Loureiro et al., 2021, Ormerod, 2020a, Pomerol, 1997, Rosenthal-Sabroux and Zaraté, 1997).

Responding to project escalation is a common occurrence during project control and Escalation of Commitment (EoC) is a well-established research phenomenon where the project manager continues investing resources while ignoring warning signs of project escalation (Staw, 1981). EoC is referred to as a biased behaviour and is often studied from a behavioural perspective (Martens and Orzen, 2021, Juarez Cornelio et al., 2021, Drummond, 2014, Keil et al., 2007, Berente et al., 2022, Flyvbjerg et al., 2022). This behaviour is explained through behavioural constructs such as optimism bias, prospect theory, approach-avoidance theory, and agency theory (Keil et al., 2000). Project control and EoC is further explained in sections 2.1 and 2.1.1 in the theoretical framework chapter.

1.2.2.4 Project Closure

Activities to end the project include reviewing the project outcome and formally documenting the deliverables (van den Ende and van Marrewijk, 2014, Westland, 2007). The literature suggest that research on this phase is limited due to academics' heavy focus on earlier stages of the life cycle (Havila et al., 2013). Research related to this phase includes stakeholder management post-project (Bengtson et al., 2018), and lessons learned (McClory et al., 2017). Lessons learned are suggested to be based on three feedback loops: 1)The project team learns from the

actual situation, 2) the lessons learned are well documented, and 3) the entire project organisation sets up learning goals and monitors these goals throughout the project (ibid). One of the mentioned activities during project control is taking corrective actions which includes terminating the project pre-maturely if necessary (Burke, 2013b). The consequences of terminating a project pre-maturely demonstrate the significance of diligent control activities.

1.3 Project Management and Operational Research

The field of OR has significantly contributed to the field of PM through the optimisation of mathematical models and project tools (Tavares, 2002). Additionally, AI algorithms have a critical role in OR and have been researched extensively (Alabas et al., 2002, Doukidis and Paul, 1990, Kobbacy et al., 2007, Ormerod, 2020a, Kunc and Katsikopoulos, 2022). The terms "logical", "analytics", "business intelligence", "algorithms" and "computational modelling" are commonly used to define the field of OR (Ormerod, 2020a). To further define OR, the related field of Operations Management focuses on organisations' management operations, whereas OR researchers study problem-solving through mathematics and the optimisation of models in specific DSSs (Kobbacy et al., 2007). This field has made a substantial impact on project planning and scheduling problems (Hazır, 2015, Kanakaris et al., 2019, Ormerod, 2020b, Pellerin and Perrier, 2019). Through its central role in DSS, OR can enhance systems through AI algorithms and techniques such as data mining (Baesens et al., 2009). More specifically, OR is suggested to influence AI-based DSSs through four perspectives: 1) Contributing to the development of AI. 2) Identifying opportunities from advancing AI capabilities to be applied in OR. 3) Displacement of OR tasks and activities by AI automation. And 4) opportunities to supervise the application of AI (Ormerod, 2020a).

The influence from OR in PM is made through project researchers applying OR models to optimise project knowledge areas (Strang and Vajjhala, 2023, Lung and Wang, 2023), or multiple models complementing each other in the form of hybrid models (Darko et al., 2023, Chang and Liang, 2023). Regardless of whether an optimisation problem uses a single or a combination of several OR models, they are set out to find the optimised solution based on a set of parameters. Solving optimisation problems is at the core of OR researchers and studies suggest applying meta-heuristics algorithms to solve complex optimisation problems (Bożejko et al., 2012). This method is based on algorithms identifying a "good enough" solution out of all possible options when information about the problem is incomplete (Liu et al., 2022). As a long-standing optimisation problem in PM, RCPSP has seen attention from many OR researchers (Bettemir and Sonmez, 2015, Coelho and Vanhoucke, 2020, Hartmann and Briskorn, 2022, Hartmann and Briskorn, 2010, Pellerin et al., 2020, Servranckx and Vanhoucke, 2019). To demonstrate the

complexity of RCPSP, it is a NP-hard problem, meaning that it has no single solution and different optimisation algorithms can perform different possible solutions (Blazewicz et al., 1983, Hartmann and Briskorn, 2022). Another common optimisation problem is identifying optimal project control points, i.e. optimising when project control measures should occur (Raz and Erel, 2000). A dynamic approach is suggested for this purpose, where an algorithm updates the control point as the project plan is updated (Sabeghi et al., 2015). Kammouh et al. (2022) argue that most project control tools have faults when suggesting mitigation actions during project disruption. The same authors state that these tools typically do not reflect project managers' complex goal-oriented behaviour of managing multiple project parameters such as keeping costs low while ensuring sufficient staffing. A further example of complex PM optimisation is found within "multi-objective problems", where the algorithm's goal is to search for a solution based on certain parameters which are set according to multiple project objectives (Balderas et al., 2022). These problems are suggested to face the following challenges: 1) The difficulty to optimise multiple-project objectives simultaneously under varying levels of uncertainty and complexity (Guo and Zhang, 2022). The method of "dynamic multiple-objective optimisation" is suggested to mitigate this and is based on updating the search parameters if new information is added (Ma et al., 2021). 2) There is ambiguity when analysing the "input-output relationship" and root causes of project issues while interpreting the output of advanced algorithms (Guo and Zhang, 2022). This is related to AI explainability and a solution is to develop explainable OR and AI models that can increase the confidence and trust in the AI model (Salih et al., 2024). 3) Another challenge is the iterative search process and interaction with the human decision-maker. The optimisation search process ends when the decision-maker is satisfied and the preferred solution is identified (Guo and Zhang, 2022). This leads to human influence on the optimisation process, also known as human-in-the-loop, and it is suggested that more interaction is necessary from the decision-maker. By including managers in the optimisation search process, they can provide key project information after each search iteration and increase the probability of finding the best solution (ibid).

1.4 Project Management and Artificial Intelligence

According to Dreyfus (1972), Simon (1965) suggested early that all human intelligence can be imitated by computers, while others have stated that the human brain is too complex to replicate and that human intelligence cannot be reproduced. Ever since the origin of AI technology during the 1950's (Kaplan and Haenlein, 2019), so called "experts" have been generous with their forecasts of what this technology can achieve. Some of these predictions have been more accurate than others. Research shows that predicting technology development is difficult and often prone to individual bias (Bonaccorsi et al., 2020). For example, in 1988 the

world chess champion Gary Kasparov was asked if he believed a computer would beat a grandmaster in chess before the year 2000. His answer was “no way”, and Hsu et al. (1990) wrote a conference paper discussing the potential of chess-playing computers at that time. As many can recall, in 1997 Kasparov declared himself defeated by IBM’s chess-playing computer “Deep Blue”. Also, Google’s computer, “Alpha GO”, disrupted the perception of what AI technology is capable of when their AI model beat the GO champion Lee Sedol in the game of GO in 2016. More recently, Open AI and Bing are two examples of companies that have developed generative AI chatbots for individuals and businesses to increase efficiency.

Goodwin (2018) argues that people’s perception of AI technology is dynamic and quickly becomes outdated as new technical developments rapidly become the norm. Further on, the mentioned researcher suggests that the expectations of technology can be ahead of the technological ability itself. This causes challenges to meet users’ expectations of new technology. The interest in improving decision-making and business efficiency has led to AI being studied through the lens of business and management research (Dwivedi et al., 2019). AI technology is today part of many business fields such as finance, marketing, and to some extent PM (Cubric, 2020). A recent review found AI to be a significant part of Industry 4.0 in PM (Jauhar et al., 2023). Contemporary research suggests AI is predominately applied within construction and IT projects (Nenni et al., 2024b). It is suggested that project researchers make conscious decisions when choosing research methods when studying AI (Müller et al., 2024).

Levitt and Kunz (1987) suggest the field of AI to impact PM through more efficient objective setting, planning, scheduling, and control through expert systems. Similarly, Holzmann et al. (2022) suggest project managers perceive AI to be useful for specific areas such as project scheduling, analysing schedule overrun, project scope, budgeting, and reporting. However, the application of AI in PM is in the early stages (Cubric, 2020), and according to Kolbjørnsrud et al. (2016), the field of management will witness the impact of AI by automating repetitive tasks and improving prediction capability. The effects on management practices are enabled through AI systems’ ability to improve prediction, data analysis and task automation, resulting in the significant potential to transform industrial, intellectual, and social human work areas (ibid). Since the entrance of AI, the use of computers to manage businesses has increased significantly (Russell and Norvig, 2016). Early AI was solely built on rule-based expert systems, whereas contemporary AI uses machine learning and more advanced analytical applications.

Regardless of the AI model, an AI tool depends on the data fed into the model. Hence, having accurate project data is key to successfully applying AI in projects. This requires project managers to ensure data management processes. Further on, it is suggested that the type of project data is adjusted depending on the project phase. Traditionally, the amount of project

information and data is limited during planning phases, and as the project progresses, more data is generated (Vanhoucke et al., 2016). On the contrary, some projects experience a high volume of data in multiple formats, and it becomes challenging to implement AI tools effectively (Martínez-Rojas et al., 2016). Additional challenges related to project data are based on project managers' data knowledge, inconsistency in project data, and the challenge to re-use data for multiple projects (Vanhoucke et al., 2016).

1.4.1 Decision Support Systems

To ease the management of projects, DSSs based on quantitative systems are used to assist project managers in their project control activities (Olson, 2020). DSSs are an overall term for computer-based systems that are applied to assist the user's decision-making (Hazır, 2015). Some of these DSSs include widely accepted project software tools, e.g. MS project, and are typically limited to the most critical project planning and scheduling functions (Desmond, 2017, Hazır, 2015). DSS is a widely applied term and can be defined in the following way: "the user is expected to interact with the system in some way to provide input or data, make choice about processing, interpret results, or come to a decision. In short, the system should help the decision maker think rationally." (Phillips-Wren et al. 2019, p. 63). Based on this definition, a DSS can be placed as an overarching term for an IT project system used by a project manager for decision-making.

Simon et al. (1987) stated early on that human decision-making could be enhanced by expert systems using OR and AI. Simon has made great contributions to AI and optimisation, e.g. he proposed that individuals process information in specific repeated patterns. Based on this theoretical concept, pattern recognition technology was developed in DSSs by integrating elements of AI (Frantz, 2003). Much of Simon's theoretical contribution can be regarded as key for developing DSSs (Pomerol and Adam, 2004). Other factors that have enabled the use of AI-based DSS in projects are the historical increase in computer power, the increasing amount of available project data, and the significance of visualising project information (Killen et al., 2020). Hazır (2015) suggests that contemporary project DSS should act as early warning sign systems for project managers, and some researchers have suggested project tools with this function (Liu et al., 2006). However, most contemporary project tools rarely have an early warning function and are instead dependent on the project manager to manually identify when corrective actions are necessary (Trietsch and Baker, 2012). Adding to the discussion is research on managers' limited ability to respond to warning signals (Benschop et al., 2020a, Compen et al., 2022, Haji-Kazemi et al., 2015). Pellerin and Perrier (2019) suggest AI project tools to increase the effectiveness of early warning sign tools. For an effective DSS, it is necessary to integrate two key features: 1) It needs to be based on an analytical model with algorithmic solutions for

simulation or optimisation purposes. 2) The DSS needs to have the ability to generate graphical interfaces for managers to visualise decision alternatives (Hazır, 2015, Jüngen and Kowalczyk, 1995).

When placing DSSs, OR, and AI in relation to each other there are overlapping areas. The thesis narrows the research scope to study project AI-based DSSs with the objective of applying OR tools to optimise project control decision-making. The thesis places DSSs on a macro hierarchy, followed by OR tools and AI-based project tools on a micro hierarchy level, see Figure 3.

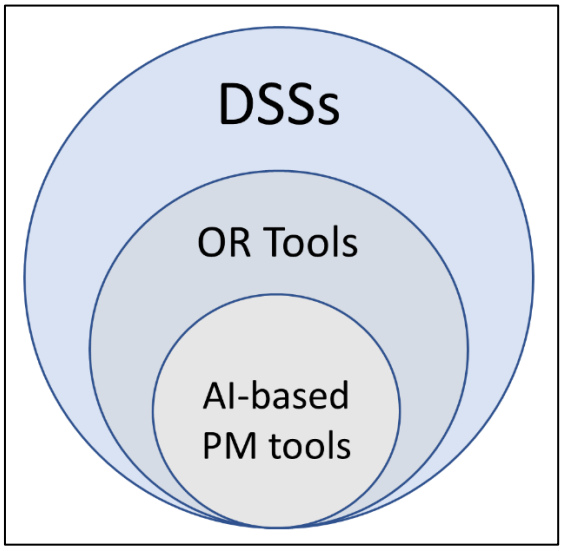

Figure 3: Thesis hierarchy of DSSs, OR Tools and AI-based project tools

1.5 Research Gap and Scope

To narrow the research scope, this thesis focuses on the project control process and the use of AI during project control. The debate on AI in PM centres on the potential of AI technology to optimise project control tools and project managers' complex tasks to act upon early warning signs due to biased behaviour. The research scope includes AI through the perspectives of OR tools and DSS, where AI algorithms are used to optimise project areas and improve decision-making for project control analysis. This is much related to the field of OR, which is known for its success in developing optimisation tools for PM areas.

Research on project managers' behaviour suggest that control mechanisms closely relate to project escalation, leading to project disruption and delays (Berente et al., 2022, Ford and Lyneis, 2020, Keil and Robey, 2001). EoC is a well-established phenomenon in the literature where the decision-maker continues to invest resources and ignores warning signs of project escalation (Ford and Sterman, 2003, Pala et al., 2015, Son and Rojas, 2011, Wang et al., 2017, Staw, 1981, Sleesman et al., 2018). However, EoC has not been studied to a far extent in relation to project managers' decision-making and behaviour when using AI-based DSSs for control

tools. Hence, there is a research gap to study the behaviour of managers during the control phase when using AI project control tools. The main research area is PM, while also including the areas of OR when studying optimisation literature and Behavioural OR to study the behavioural aspects of AI and OR tools.

1.6 Research Aim

This thesis aims to understand how project managers' behaviour is impacted by AI. The research will study project managers' behaviour when using AI control analysis as early warning signs systems. The aim will be achieved by answering the research questions and the research objectives.

1.6.1 Research Question and Objectives

Due to the field of AI in PM being a novel research field, the thesis began in the autumn of 2019 to explore the literature in an exploratory manner. When discovering the fact that the literature was at the time missing a structured synthesis of the AI in PM literature, the choice was made to perform a Systematic Literature Review (SLR) on this field. For this purpose, the following research questions were formed:

- *What themes define the project management and AI literature?*
- *What trends can be identified in the project management and AI literature?*
- *What future research agenda can be identified from the project management and AI literature?*

To answer the above questions the thesis formulated research objective 1 to identify research gaps in the literature of PM and AI, see Table 1. The key output of the SLR was the identified research gap to study project managers' decision-making and behaviour when using AI analysis for project control. To target this gap, the main research question was formulated and answered through three main objectives presented in Table 1.

Main research question:

How do behavioural theories or constructs affect project managers during the project control process when using Artificial Intelligence technology as early warning sign tools?

1.6.2 Research Structure

The research structure is divided into three phases, see Table 1. Each phase is characterised by a research paper and presents specific research contributions. Phase 1 consists of a SLR

synthesising the literature of AI in PM research. A key contribution of the SLR is the proposed research agenda and identified gap. This research gap shaped the main research question, which is the foundation for the empirical research in phases 2 and 3. The empirical research papers are based on semi-structured interviews with 22 project managers with experience from using AI for project control analysis. The empirical study adopts the strategy of Grounded Theory to collect and analyse the interview data. The research findings are presented through Causal Loop Diagrams (CLD) and the key contributions involve behavioural constructs related to EoC and De-escalation of Commitment (DoC).

Table 1: Research Structure

Phase:	**Phase 1**	**Phase 2 and Phase 3**
Research question:	Initial RQs: What themes define the project management and AI literature? What trends can be identified in the project management and AI literature? What future research agenda can be identified from the project management and AI literature?	Main RQ: How do behavioural theories or constructs affect project managers during the project control process when using Artificial Intelligence technology as early warning sign tools?
Research objective:	Objective 1: Identify research gaps in the literature of AI in project management	Objective 2: Capture project managers' mental models when using AI for project control. Objective 3: Identify variables that influence project managers' behaviour when using AI during project control. Objective 4: Identify behavioural heuristics that influence project managers' behaviour when using AI for project control.
Theoretical framework:		Descriptive Decision Theory
Research format:	Systematic Literature Review Research paper	Empirical research papers
Research method:	Planning, conducting, reporting (Tranfield et al., 2003)	Semi-structured interviews Causal Loop Diagrams Grounded Theory
Main research contribution and output:	Synthesis of AI in project management literature Research agenda Identified research gap to study project managers' behaviour when using AI	The behavioural construct of "The Wait Effect" The behavioural construct of "Override AI Bias"

1.6.3 Research Contribution

Research objective 1 The following section summarises the research contributions related to the research questions and objectives. The SLR in phase 1 identifies that project researchers use different approaches depending on the research objective. The most common approaches

include applying AI algorithms to optimise project knowledge areas, and conducting empirical research to study project practitioners' perceptions of AI technology. Researchers applying AI for optimisation closely relates to OR, where researchers use mathematics and quantitative techniques to optimise decision tools and DSS. The empirical approach is commonly based on qualitative data collection or quantitative questionnaires. The theoretical findings from the SLR include that project researchers are able to identify suitable approaches and works as a foundation for academics to comprehend the field of AI in PM. Further on, practical implications include that project practitioners can use the findings to apply AI algorithms and models for specific project areas and to understand which approaches are efficient when applying AI in projects. Additionally, the SLR identifies the research gap in studying project managers' behaviour when using AI project control tools and suggests a future research agenda for the PM community.

Moving on, the contributions from the empirical research objectives are summarised as following:

Research objective 2: Capture project managers' mental models when using AI for project control.

The research contributions include demonstrating project managers' mental models through cause-and-effect feedback loops. The loops are based on CLDs and explain what behavioural dynamics occur when project managers use AI for project control. The CLDs are significant research contributions and explain reinforcing and balancing behaviour.

Research objective 3: Identify variables that influence project managers' behaviour when using AI during project control.

The feedback loops are based on variables that impact project managers' EoC and DoC behaviour. The variables are key contributions to PM and Behavioural OR literature as they provide new insights into the behaviour of project managers using AI.

Research objective 4: Identify behavioural heuristics that influence project managers' behaviour when using AI for project control.

The thesis contributes with two main behavioural constructs: 1) "The wait effect" which explains how project managers continue the behaviour of EoC due to low "willingness to take corrective action" and high "confidence in original project plan". 2) "Override AI bias" which explains how managers enforce DoC based on "information asymmetry". Both constructs occur due to managers' low trust in the AI model.

1.7 Introduction Summary

The thesis is structured in three phases where the first phase is based on the SLR and answers the initial research questions with the objective to identify research gaps in the literature of AI in PM. The SLR identifies the research gap that forms the main question: How do behavioural theories or constructs affect project managers during the project control process when using Artificial Intelligence technology as early warning sign tools? The main research question is the foundation for the empirical research in the second and third phases.

The introduction presented PM as the main research topic with the related areas of OR and AI through DSSs. PM has seen influence from OR, and it is suggested that AI will enrich the optimisation of project areas. Considering the literature on project managers' behaviour during project escalation while using AI-based DSSs is limited, it becomes critical to research project managers' behaviour and decision-making when using AI analysis during project control. These topics are expanded in Chapter 4, Chapter 5, and Chapter 6 through individual research papers. The following Chapter 2 demonstrates the thesis' theoretical framework in project control and Behavioural Decision Theory.

Chapter 2 Theoretical Framework

The thesis adopts the theoretical framework of project control, analytical AI and decision theory. To study project managers' behaviour and decision-making when using AI-based DSS and OR tools for project control analysis, the thesis adopts Behavioural and Descriptive Decision Theory. Related to this area, Behavioural OR (BOR) is an effective research lens that studies decision-makers' behaviour when using OR tools. Additionally, the chapter includes the literature on project decision-making and heuristics and biases (HB). The chapter guides the reader through the thesis' theoretical framework based on the key areas of project control, analytical AI, and BOR.

2.1 Project Control

A traditional control measure is the concept of "the iron-triangle" which includes the limited resources of time, cost, and performance or quality, see Figure 4. The triangle is an example of when project control measures are applicable in a cross-industry environment (Lock, 2014). The triangle is a fundamental part of PM literature where time, cost, and quality are measured to analyse the project performance. However, some researchers suggest adding elements of risk, stakeholders perspectives, scope, and requirements to reflect a complex project environment (Pollack et al., 2018, Todorović et al., 2015). The dynamics of the triangle demonstrate a trade-off problem where a change in one element affects one or both of the other, e.g. increasing the cost in Figure 4 will likely impact the other areas.

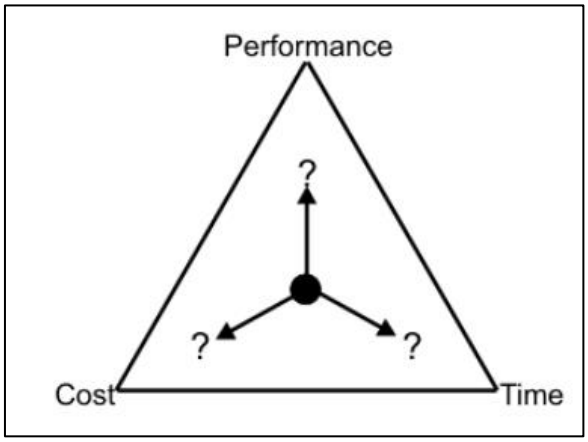

Figure 4: Iron Triangle (Lock, 2014)

Project control literature suggest defining project control through the activities of "planning", "measuring", "monitoring" and "taking corrective action" (Rozenes et al., 2006). Further definitions of control activities are "evaluating project performance", "forecasting of the final project duration", "optimal timing of control points", and "act on early warning signals through

corrective actions" (Pellerin and Perrier, 2019). However, this thesis adopts the following three phases to define control activities by Olawale and Sun (2013):

1) Setting baselined standards and the performance criteria which the project will be measured on. This is a critical part of the control phase. However, this activity is not central to the research scope. The thesis refers to the sections of 1.2.1 and 6.2.1 for literature on project success criteria.

2) Measuring the actual project progress against the baselined plan. As mentioned previously, project managers commonly use quantitative project tools and DSSs to measure project progress (Hazır, 2015, Willems and Vanhoucke, 2015). Established control tools are Monte Carlo simulation, which simulates future outcomes of the project and Earned Value Management (EVM) which measures the completed work compared with the planned work (Acebes et al., 2014, Hazır, 2015, Rozenes et al., 2006). EVM is an example of a contemporary control tool which measures the project progress based on the value of work completed compared with budget and schedule (Rozenes et al., 2006, Acebes et al., 2014). EVM is further enhanced by including AI techniques (Hajiali et al., 2020, Wauters and Vanhoucke, 2016).

3) Respond to early warning signs of project escalation by taking corrective actions. If a project's performance deviates from the plan it is referred to as project escalation. When studying project managers' decision-making during escalation, the literature refers to the behaviour through the phenomenon of EoC. This phenomenon is explained further in the next section.

2.1.1 Escalation of Commitment

Mentioned in the introduction, EoC is referred to as a biased behaviour and is often studied from a behavioural perspective (Martens and Orzen, 2021, Juarez Cornelio et al., 2021, Drummond, 2014, Keil et al., 2007, Berente et al., 2022, Flyvbjerg et al., 2022). This phenomenon can be explained through the common PM behavioural constructs of optimism bias, prospect theory, approach-avoidance theory, and agency theory (Keil et al., 2000). It is suggested that decision-makers who intensely spend time on their decisions actually perform worse than other decision-makers (Kotzian, 2025.)

Optimism bias is referred to as an overall term for several cognitive biases and is suggested to be active within project control, project initiation and project planning (Meyer, 2014, Son and Rojas, 2011, Stingl and Geraldi, 2017a). It is explained as an overestimation of positive outcomes and an underestimation of negative outcomes (Stingl and Geraldi, 2017a). It is also suggested to be referred to as overconfidence and confirmation bias (Loch, 2017, Winch, 2013).

Prospect theory, also referred to as “the sunk cost effect”, explains EoC through the decision-maker is prone to a risk-seeking behaviour when faced with certain losses and are risk-averse when faced with certain gains (Kahneman and Tversky, 1979, Wang et al., 2017, Wang et al., 2020b, Staw, 1981). In a scenario of project escalation, the project manager continues investing in the failing project with the expectation of saving the project and with the perception of losing the previously invested resources if the project is stopped (Keil et al., 2000).

The approach-avoidance theory is also referred to as “the completion effect”, where escalation is enforced through immediacy to the project completion (Keil et al., 2000). Approach-avoidance can be explained as a “pull” for project completion, whereas prospect theory is referred to as a “push” (Mann, 1996). Additionally, this behavioural construct is explained through the concept of “the 90% syndrome”. Where the perception of the project as “almost completed” justifies managers to continue the escalation (Buxton and Rivers, 2014, Ford and Sterman, 2003).

Agency theory is explained by project objectives are misaligned and managers are driven by personal goals. Additionally, the theory is explained through the concept of “goal incongruence“ where the project goals are inconsistent and driven by “information asymmetry” (Keil et al., 2000). Agency theory is driven by self-interest and does not focus on achieving the project objectives (Sleesman et al., 2018). This behaviour is based on the roles of an “agent” and a “principal”. The agent is given the decision-making mandate on behalf of the principal. However, goal misalignment occurs between the mentioned roles, and the agent continues the project escalation based on a personal agenda and self-interest (Jensen and Meckling, 1976, Keil et al., 2000).

Further on, several concepts complement EoC in project teams. Through “optimism traps”, team members influence each other by making optimistic estimations (Buehler et al., 2005). “Perspective differences” are based on stakeholders’ different views of the severity of the escalating (Keil and Mähring, 2010, Sleesman et al., 2018). As a result, the mentioned researchers suggest mitigation actions can be implemented after negotiation and discussion. This leads to compromises and slower effective remedial actions. In such situations, the different perspectives enable further project escalation. Additionally, “authority pressure” is a source of EoC through team members feeling intimidated to share their concerns about a failing project (Sleesman et al., 2018). According to Sleesman et al. (2018), authority pressure is related to project reporting and is considered part of escalation activities. According to Wang et al. (2020b), reporting activities are separated from EoC and the project control phase. This thesis follows Sleesman et al. (2018) and includes reporting activities as part of the control phase.

2.1.1.1 What is perceived as de-escalated action?

While EoC has seen long-term attention from researchers, the related DoC literature has not seen the same attention (Pala et al., 2015, Pan et al., 2006). The DoC literature agrees that any action that redirects the project in a different direction is considered a DoC action. However, it is unclear how to define the action when managers choose "to do nothing" and are passive during the escalation. It is currently discussed whether this is to be described as an "action" or as an "inaction" (Feldman and Wong, 2018). It is suggested that project teams can enhance DoC by providing support for members experiencing EoC, ensuring psychological safety for individuals to raise concerns of escalation, and integrating new attitudes and behaviours to end the negative cycle of EoC (Pan et al., 2004).

2.2 Analytical AI

It is necessary to adopt an AI definition for this thesis and to demonstrate the type of AI used by the included 22 individual research participants. According to Russell and Norvig (2016), AI is defined as a computer system with the ability to mimic human cognitive abilities in learning, speech recognition and problem solving. Whereas Kaplan and Haenlein (2019, p.17) use the following definition:

"...a system's ability to interpret external data correctly, to learn from such data, and to use those learnings to achieve specific goals and tasks through flexible adaption."

These definitions help clarify AI and demonstrate that there is no universal AI definition. This thesis acknowledges the above definitions and complements them with the definition by Huang and Rust (2018) who classify AI through four categories; mechanical, analytical, intuitive and empathetical. Huang and Rust (2018) explain the mechanical AI to be found in rule-based AI systems, whereas the other three categories include different elements of machine learning. The thesis adopts Huang and Rust (2018) definition to classify different types of AI, see Table 2. "Analytical AI" is the most applied type of AI when optimising analytical decision-making and this thesis adopts this classification in the theoretical framework (Huang and Rust, 2018).

Table 2: Categorisation of AI (Huang and Rust, 2018)

Type of Artificial Intelligence	Definition	Example of application area: Customer support
Mechanical AI	Learn and adapt at the minimum	Scripted response to simple customer issues
Analytical AI	Learn and adapt systematically based on data	Analyse customer' problems
Intuitive AI	Learn and adapt intuitively based on understanding	Understand why customers complain (contextual understanding)
Empathetic AI	Learn and adapt empathetically based on experience	Emphasise with customers (calm down customers)

Several researchers promote a collaborative approach for business organisations when working with AI technology (Davenport and Ronanki, 2018, Kaplan and Haenlein, 2019, Kolbjørnsrud et al., 2016, Wilson and Daugherty, 2018). Such a collaborative approach is based on viewing AI as an opportunity to enhance current management practices rather than a threat towards replacing workers through automation (Davenport and Ronanki, 2018, Kolbjørnsrud et al., 2016, Wilson and Daugherty, 2018). The PM community has discussed the practical implications of AI in PM and research suggests that AI systems may replace certain project roles (Hirman et al., 2019). For example, project support roles may see a significant impact from AI technology (Taylor, 2021). The above-mentioned authors are not an exhaustive list of researchers studying AI in PM. However, they provide an overall discussion of how analytical AI may impact the project profession. This PhD thesis assumes that AI benefits project managers by viewing AI as an enhancement tool to assist in decision-making rather than a technology for automation that will replace project roles.

2.3 Decision Theory

Decision theory has influenced many fields in social sciences, including e.g. Behavioural Economics and Psychology. Major influences in decision-making are the publications of Kahneman and Tversky through the concepts of HB and prospect theory (Kahneman and Tversky, 1979, Tversky and Kahneman, 1974). Additional significant work is done by Gigerenzer and colleagues who introduced the concept of fast and frugal (FF) (Gigerenzer, 2004, Gigerenzer and Todd, 1999). HB and FF are further discussed in sections 2.4.2 and 2.4.3. Early discussions in decision theory focused on rationality and assumed that individual decision-makers are capable of making rational decisions and will always choose the option that provides the most value, or utility (Savage, 1954). A key pillar in decision theory is the concept of "utility", or "expected utility theory", and can be traced back to Daniel Bernoulli in the 18th century (Tversky, 1975). Expected utility was further explained by Von Neumann and Morgenstern (1947) through the idea that decision-makers behave rationally, are able to foresee the consequences of their

decisions and will choose the option that provides maximum expected utility. Over time, flaws in this theory came to light and researchers added "subjective expected utility theory", where individuals' subjectiveness is given a significant role (Farquhar, 1984, Savage, 1954).

The field developed into using the terms "risk" and "uncertainty", which are central to contemporary decision theory. Decision-making theory is seen through three scenarios: 1) Decision-making under certainty, where the problem is known and all variables and consequences of decisions can be foreseen. 2) Decision-making under risk, implies partial information and the problem cannot be predicted. 3) Decision-making under uncertainty where information and causes to the problem is incomplete (Marugán and García Márquez, 2017). This thesis includes decision-making during the second and third points, and studies project managers' decisions under risk and uncertainty.

A critical concept in decision theory was the introduction of "bounded rationality" by Simon (1972). This concept explains the decision-making process of providing a *satisfying* rather than an *optimised* decision (Gigerenzer and Goldstein, 1996). The increased interest and understanding of individuals' biases and behaviour allowed sub-fields of decision theory to develop. The next section explains Behavioural Decision Theory and presents the underlying theories of Descriptive-, Normative- and Prescriptive decision theory.

2.4 Behavioural Decision Theory

To complement decision theory with aspects of individuals' behaviour, researchers adopted Behavioural Decision Theory (Edwards, 1961). It is a widely accepted research lens when studying individuals' decision-making and includes three different paradigms: Descriptive-, Normative-, and Prescriptive Decision Theory (Jones, 1999). The thesis adopts Descriptive Decision Theory, which explains how decision-makers *actually* make decisions based on uncertainty and risk rather than how they *should* make decisions (Einhorn and Hogarth, 1981). The other paradigms study optimal decisions, where the normative view does not consider individuals' limitations in rationality and seeks ideal decision outcomes, and the prescriptive view prescribes rules and methods for how individuals can optimise decisions (Bell et al., 1988). Adopting the descriptive view aligns with Stingl and Geraldi's (2021) conclusion that contemporary project research favour a descriptive paradigm due to the typical complex project environment. The same authors state that descriptive research is more valuable to study than the prescriptive and normative views since ideal decisions are challenging to establish in complex project environments. Behavioural decision-making is defined as: "*... endeavours to understand the actual influences on actors in making choices.*" (Muallaly, 2014, p. 519). As this definition states, the "actor" has a key role in decision-making and has four key characteristics:

1) Is an entity that is given authority to make an impact with a decision. 2) Is given freedom to make a decision. 3) Must make intentional decisions. 4) Must be able to reflect on decisions (Dietz and Burns, 1992). To put this in context to the thesis, the project manager is the "actor" and is given the authority and freedom to make intentional decisions while being able to reflect.

Mentioned previously, another key concept when applying Descriptive Decision Theory is bounded rationality, which states that individuals are limited in their decision-making due to bounded knowledge, cognitive limitations and time pressure (Simon, 1972). Bounded rationality suggests that decision-makers' knowledge is incomplete and individuals' mental models are largely simplified and imperfect (Sterman, 2000). Mental models is a key concept for decision theory and is demonstrated in section 3.3.1. There are different views on defining "rationality" and there is no clear definition (Gigerenzer and Selten, 2001). Katsikopoulos (2014) suggests categorising the various perspectives of bounded rationality through an "idealistic" and a "pragmatic" standpoints. Researchers with an idealistic view argue that rationality stands for optimisation, completeness, continuity, and consistency (Walsh, 1996). On the other hand, the pragmatic stand argues that it is reasonable to expect some faults in individuals' rational decision-making. The pragmatic view argues that individuals do not make irrational decisions by default. Instead, individuals rationally justify their actions to a certain extent while unaware of some of their biases (Katsikopoulos, 2014). This explanation of rationality suggests that individuals use behavioural heuristics, or rule-of-thumbs, to simplify decisions based on limited available information to perform acceptable and satisfying decisions. This is in line with the original work by Simon (Katsikopoulos, 2014), and is a commonly adopted view among behavioural and descriptive decision researchers (Kahneman and Tversky, 1979, Simon, 1972, Sterman, 2000). The thesis adopts the pragmatic view and assumes that project managers are rational decision-makers who make decisions to the best of their ability by absorbing the available information while having cognitive limitations.

2.4.1 Heuristics in Decision-making

The understanding of heuristics, biases, and subjective judgement became accepted in decision theory around the 70s (Kahneman and Tversky, 1979, Kahneman and Tversky, 2013). It is suggested that individuals rely on heuristics to make everyday judgements and decisions, and are explained as cognitive short-cuts. They are seen as useful reasoning short-cuts for individuals' decision-making process (Tversky and Kahneman, 1974). These cognitive short-cuts are closely related to the previously mentioned concept of bounded rationality, where individuals are limited in their capacity to take in all available information prior to a decision (Simon, 1972). Heuristics often go unnoticed by the individual and if they are recognised, the decision-maker can avoid certain biases (Purvis et al., 2004). Cognitive biases are stated as the

reason why individuals cannot make optimal decisions and follow normative decision theory (Bonaccorsi et al., 2020).

The following definition of heuristics states:

"*... heuristics are cognitive strategies for judgement and decision-making that make use of a small subset of the available information through specific rules. Individual decision makers use those strategies adaptively to choose a "good enough" alternative for a specific decision or judgement problem*." (Stingl and Geraldi, 2021, p.5).

The above definition highlights using cognitive strategies while using a small set of the available information to make "good-enough" decisions. Further characteristics of decision-makers' heuristics are suggested by Atanasiu (2021): 1) The decision maker is "frugal", i.e. economical or sparing with the use of time, effort, information, and processing capacity. 2) The solution is not optimised but seen as "good enough" from an effectiveness perspective. 3) The problem is complex and "ill-defined". 4) Managers' behavioural heuristics use fewer resources and do not apply analytical algorithms. The last point by Atanasiu (2021) is not aligned with this thesis and BOR literature and is therefore excluded. A core principle of BOR is to study decision-makers' heuristics when using analytical tools through OR and DSS. The above definition and characteristics explain how heuristics are used as a simple cognitive tool when individuals face complex problems. It is a simple strategy when problems are not clearly defined based on limited, or too much information. The heuristic strategy simplifies the available information to make a "good enough" decision in a timely manner.

There are different views on how to divide the literature of heuristics (Stingl and Geraldi, 2017b). The concept is suggested to be referred to as an "adaptive toolbox", that is made up of simple building blocks (Gigerenzer and Selten, 2001). Whereas Bingham and Eisenhardt (2014) suggest using the following three categories: 1) "simple rules", 2) "fast and frugal" (FF), and 3) "heuristics and biases" (HB). The two latter categories have seen the most attention in decision-making literature, whereas "simple rules" is based on improvisation and is not commonly referred to in project research (Bingham and Eisenhardt, 2011, Stingl and Geraldi, 2021). Hence, the thesis will continue to explain the differences of the concepts FF and HB.

2.4.2 Fast and Frugal

According to Gigerenzer et al. (1999), FF applies fast-thinking heuristics rather than time-consuming analytical decision tools. It is stated that Gerd Gigerenzer is the leading academic in this heuristic paradigm (Flyvbjerg, 2022). Noticeable is the inconsistency in the literature when referring to FF. This concept is also referred to as "adaptive heuristics" or "simple heuristics"

(Brighton and Gigerenzer, 2012, Gigerenzer and Sturm, 2012, Stingl and Geraldi, 2017b, Stingl and Geraldi, 2021). These terms are used interchangeably in the literature (Gigerenzer and Gaissmaier, 2011). However, the thesis refers to the term FF.

Gigerenzer and Sturm (2012) suggest that FF is a preferred decision paradigm because it produces the same or better results than more time-consuming decision processes. Research suggest that FF is useful for complex and uncertain decision-making as it requires relatively low effort while being sufficient in making acceptable and accurate decisions (Stingl and Geraldi, 2021). More complex decision-making processes can be performed more accurately but may require more effort and resources. This is explained through the "accuracy-effort trade-off", where higher effort leads traditionally to more accurate decisions (Mousavi and Gigerenzer, 2014). However, the FF paradigm argues that individuals can benefit from faster decisions based on low effort with an accepted accuracy rather than increasing the time and efforts of making decisions for only a marginal increase in utility (Gigerenzer and Sturm, 2012). The FF view argues for more effective heuristics by suggesting that the accuracy-effort trade-off does not affect FF decision-making negatively.

Stingl and Geraldi (2021) suggest applying the FF when studying project decision-making. They argue that practitioners camouflage their judgment and intuition with rational justifications and DSSs. FF avoids determining behaviour as inherently biased or wrong. According to the researchers, FF opens opportunities for identifying why and how an individual arrives at a certain decision. According to Flyvbjerg (2022), FF stands for a "positive" aspect of heuristics, allowing individuals to learn from previous mistakes and not allowing errors and biases. Whereas HB is suggested to represent the negative consequences of heuristics in the form of biases and errors, tolerating fault answers to a certain extent. The two views have some similarities and key differences. Both of the views agree that heuristics are useful for simplifying complex decision-making. However, the FF view argues for a higher accuracy and effectiveness (Brighton and Gigerenzer, 2012, Gigerenzer and Sturm, 2012, Stingl and Geraldi, 2017b, Stingl and Geraldi, 2021). These concepts should not be seen as competing ideas but rather as complementing models to understand the area of decision-making heuristics (Flyvbjerg, 2022). The following section presents the concept of HB.

2.4.3 Heuristics and Biases

The discussion of HB and its relevance to project managers is evident through the debate between Daniel Kahneman and Bent Flyvbjerg. The HB view suggests biases are based on unintentional behaviour, while Flyvbjerg (2008) argues that this is a simplified view of project managers' behaviour. The main argument of Kahneman (1994) is that individuals are prone to

bounded rationality to a further extent and will have continuous biased behaviour through e.g. "optimism bias". On the other hand, Flyvbjerg (2008) states that managers can learn from previous experiences and deliberately ignore these lessons learned. Essentially, Flyvbjerg believes managers are more capable of learning from previous mistakes, whereas Kahneman suggests managers are not immune to biases even after learning from previous experiences. In the context of Descriptive Decision Theory in PM, the discussion of HB and FF is based on whether project managers' decisions inherently contain cognitive biases and should be avoided or if they are efficient techniques to provide accurate decisions.

PM researchers have adopted both FF and HB views, which complement explaining project managers' decision-making and behaviour. In practice, it can be assumed that practitioners fluctuate between FF and HB. The research thesis benefits from both perspectives. However, the thesis focuses on biases among managers, and while including some factors of individuals' learning from previous experiences, it is assumed that the thesis studies managers based on the assumption that they are not immune to biases. Hence, the research is closer to the view of HB than FF.

2.5 Behavioural Operational Research

The introduction section 1.3 presented the field of OR and studying behavioural aspects of OR is traced back to the 1960s and 70s. However, it is not until recent decades that this field has become widely accepted (Hämäläinen et al., 2013). The interest in understanding the user of OR tools and the individual decision-maker in the context of OR has led to the development of BOR (Kunc and Katsikopoulos, 2022, Kunc et al., 2016, Laengle et al., 2017, White, 2016). This field is influenced by other scientific fields, such as psychology, economics, sociology, and OR (Bendoly et al., 2010). It differentiates from the mentioned fields by studying the behaviour of individuals when using OR tools and DSSs (Becker, 2016), and has grown into an established research area (Franco et al., 2021, Johnson et al., 2018, Kunc and Katsikopoulos, 2022). Royston (2013) suggests that BOR is the practice of "real-world" decision-making that incorporates individuals' behaviour. This field facilitates the understanding beyond OR tools and studies what behaviour comes into play when using OR tools (Hämäläinen et al., 2013). This is an important area to study as there are often gaps between individuals' assumed and actual behaviour (Luoma, 2016). To clarify the meaning of BOR, the thesis adopts the following two definitions:

"*Behavioural OR is the sub-discipline of OR that… studies the way in which insights into human behaviour can be integrated in OR techniques and the way in which the use of OR techniques shapes and is shaped by human interactions…"* (Becker, 2016, p. 813).

The above definition includes how human behaviour is integrated into OR techniques. The below definition considers aspects of psychology, cultural, cognitive and emotional factors on analytical OR tools:

"... it is the study of the effects of psychology, cultural, cognitive and emotional factors on our thinking and action with the use of (advanced) analytical methods and/or model, to solve complex problems, support perplexing decision and improve our ever-changing organizations."(White et al., 2020, p. 5).

The definitions complement each other by mentioning the impact of OR tools on human behaviour and vice versa. The thesis further defines BOR through the three perspectives suggested by Kunc et al. (2016): 1) "Behaviour with models" shows actual human behaviour and heuristics applied when using OR models. 2) "Behaviour in models" includes incorporating individuals' behaviour in BOR models. For example, modelling individuals as passive entities or discrete events. 3) "Behaviour beyond models" represents external behaviour beyond the individual through, for example, policy changes resulting from OR models. Since this thesis explains the descriptive behaviour of project managers using AI-based OR tools, the research is aligned with the first aspect, behaviour with models. However, it is challenging to ignore the perspective of behaviour beyond models due to the research having further implications beyond the specific model.

2.5.1 Project Management and Behavioural OR

In the extended book edition of BOR by White et al. (2020), the context of BOR and PM is reviewed by Wang et al. (2020b). In this review the authors identify 117 papers on project stakeholders' behaviour, however, less than 20% of the papers apply OR techniques and are considered to fall under the field of BOR. The authors conclude that there is a large body of knowledge regarding project managers' biased behaviour. However, BOR in PM is still a relatively narrow research field.

A common method to study project decision-making is through CLD (Ford and Lyneis, 2020, Kunc, 2016, White et al., 2020, Lyneis and Ford, 2007, Pala et al., 2015, Repenning, 2000, Rodrigues and Bowers, 1996, Rodrigues, 2000, Son and Rojas, 2011, Sterman, 2000, Wang et al., 2017). Through CLD and System Dynamics simulation, researchers study project managers' behaviour during project escalation and their remedial decision-making. These methods are used to study EoC behaviour based on optimism bias (Son and Rojas, 2011) and prospect theory (Wang et al., 2017). Whereas Wang et al. (2020a) applied simulation to study the remedial actions of individual projects from a project portfolio perspective. An additional study applied CLD as a de-escalation technique for projects (Pala et al., 2015). Additional soft OR methods in

BOR are suggested by Wang et al. (2020b) to be Problem Structuring Methods and Rich Pictures. This research thesis adopts the qualitative method of CLD and the research findings are presented based on this method. CLD modelling is explained in the Chapter 3 Research Methodology.

So far the theoretical framework has guided the reader through Behavioural Decision Theory and Descriptive Decision Theory. The thesis presented the pragmatic view of bounded rationality and adopts BOR through the view of behaviour with models. Aligned with BOR and PM literature, the thesis adopts the modelling technique of CLD to present the research findings.

2.5.2 Different Schools in Project Decision-making

In recent years, project decision-making has seen an interest in studying HB among project managers (Chen et al., 2023, Flyvbjerg, 2021, Lawani et al., 2023). Stingl and Geraldi (2017a) adopted the work by Powell et al. (2011) and divide the project decision-making literature into three schools of thought: "reductionist", "pluralist", and "contextualist". The thesis adopts this categorisation, and the three schools explain contemporary project decision-making through different ontology and epistemology views:

1) **The reductionist** view studies decision-making mainly through quantitative methods and adopts a positivist view by analysing deviations from normative to descriptive decision-making. In this view it is common for researchers to study bias behaviour such as EoC constructs of overoptimism, prospect theory and agency theory (Keil et al., 2007, Keil et al., 2000, Liu et al., 2019, Son and Rojas, 2011). The concepts of HB and bounded rationality are common in this school (Stingl and Geraldi, 2017a). The thesis is most aligned with the reductionist school. However, the thesis shares the application of qualitative research with the pluralist and contextualist schools.

2) **The pluralist** school is based on pragmatism and is represented by the concepts of "strategic misinterpretation" (Flyvbjerg, 2007, Lefley, 2006, Winch and Kelsey, 2005), "opportunistic behaviour" (Drummond, 1995, Haji-Kazemi et al., 2015), and "negotiation" (Winch and Kelsey, 2005). This view shares the reductionist practice of comparing normative and descriptive decision-making. Instead of the reductionist characteristic of optimism, the pluralist school is defined by opportunism and focuses on behaviour influenced by personal interests and political agendas. As the name entails, the pluralist view adopts multiple approaches, i.e. quantitative, qualitative and mixed methods (Stingl and Geraldi, 2017a).

3) **The contextualist** school takes an interpretive view and is defined through "sense-making" and qualitative research. It studies the process of how decisions are made and the context in

which they take place, rather than defining the “right” decision (Stingl and Geraldi, 2017a). It considers the context of the decision-making process and the sensemaking underlying the decision (Alderman et al., 2005, Lenfle, 2011). As opposed to the other schools, the contextualist view studies successful outcomes in a project. For example, the Sydney Opera House experienced overruns in time and costs during construction but is today considered a success and a landmark for the city of Sydney (Musca et al., 2014).

It is important to notice that the boundaries of the different schools are not distinctive, and different influences and methods are used across the schools (Stingl and Geraldi, 2017a). This thesis is much aligned with the descriptive research in the reductionist school. In the context of this thesis, the reductionist school distinguishes itself through the concepts of HB, bounded rationality, and research in the underlying behavioural aspects of EoC and behavioural biases.

2.6 Summary of Thesis Chapters and Theoretical Framework

The theoretical framework has guided the reader through Behavioural Decision Theory and justified adopting Descriptive Decision Theory through the pragmatic view of bounded rationality. The debate of descriptive decision-making is centred around behavioural heuristics, where the concepts HB and FF are presented. The thesis explained that HB is most relevant for the research based on the focus on project managers’ biased decision-making. To answer the research question, the thesis adopts the lens of BOR and the view of behaviour with models where individuals’ behaviour and decision-making are studied when using OR tools. Aligned with BOR and PM literature, the thesis adopts the modelling technique of CLD to present the research findings. Figure 5 demonstrates how the overall key research topics PM, AI, and BOR are related.

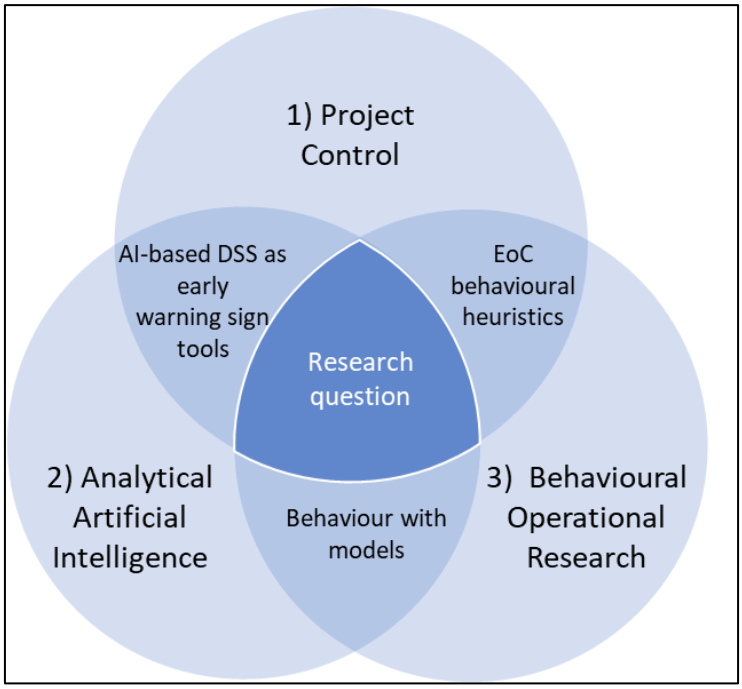

Figure 5: High level theoretical framework and relationship of key research areas

The figure represents the thesis' research scope which forms the thesis's key contribution and is formulated through the research question. The connection between these areas is presented in the figure and the research question is broken down into the three key research topics:

How do behavioural theories or constructs affect project managers during the project control process when using Artificial Intelligence technology as early warning sign tools?

1) The main research topic of PM is narrowed down to project control and the activities of setting performance standards, comparing actual progress against set standards, and taking corrective action against project escalation. In the context of this research thesis, this is done with the assistance of AI-based DSS where these systems act as early warning sign tools for project.

2) AI is applied through analytical AI with the literature of OR and DSSs within project control. The scope is narrowed down to focus on AI as DSSs by studying project managers' "behaviour with models".

3) The topic of BOR includes project managers' documented challenges to act on project escalation. In this area behavioural constructs explain the phenomenon of EoC. The thesis presents a research gap studying project managers' behaviour and decision-making using AI-based DSS for control analysis. Hence, this thesis contributes significantly to this emerging field.

Chapter 3 Research Methodology

The empirical research adopts an interpretivist research philosophy. Figure 6 presents the research methodology and demonstrates that phase 1 of the thesis is based on a SLR and the method of Tranfield et al. (2003) which includes the following three steps of: planning, conducting, and reporting. The final 63 papers were reviewed through a thematic analysis. Phases 2 and 3 apply the interpretive research philosophy, followed by an abductive approach and a qualitative research design based on a Grounded Theory research strategy with an open coding process. The final theory development is presented through CLD models.

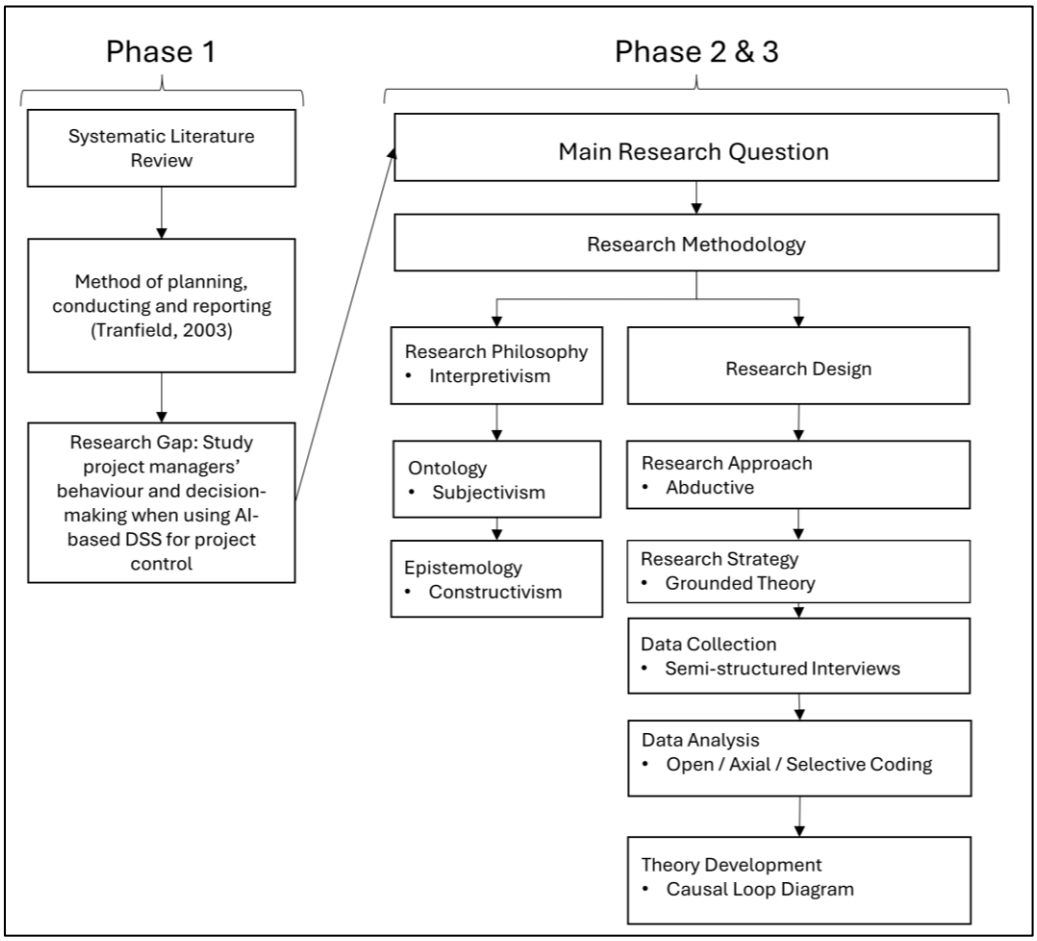

Figure 6: Research Methodology

3.1 Interpretivist Research Philosophy

The research follows an exploratory nature which is aligned with studying an emerging research field such as project managers' behaviour when using AI (Glaser and Strauss, 2017). The research question guides the choice of research methodology, and it is important to discuss the underlying assumptions of this research. This is done by defining the research philosophy. The philosophy reveals how research participants are viewed and their perspectives. Defining the

research philosophy involves understanding how reality is constructed (ontology), how the creation of knowledge is viewed (epistemology), and the significance of ethics and values (axiology) (Walliman, 2010).

Some academics believe the researcher should stay as objective as possible to the actual research topic (Hair et al., 2016). This view allows researchers to stay unbiased and to perform an objective study. This is a traditional scientific school of thought and is commonly found in the natural sciences and positivist philosophy. Positivism is based on an objectivist ontology and typically uses quantitative research methods (Myers, 2020). This philosophy relies on objective measurements and realism, aiming to find one truth to a research question. When studying a social phenomenon, the positivist stand is criticised as being too deterministic (Hennink et al., 2020). Studying a phenomenon in social science commonly requires understanding the different perspectives of research objects, which requires a different philosophical stand than positivism offers. This is because the various perspectives of research participants are typically insufficient to be studied through positivist objective measurements. Additional critique towards the positivist paradigm is seen specifically in PM, where it is suggested to not represent a typical complex project environments (Cicmil, 2006).

On the other side of the spectrum from positivism is interpretivism. Where different perspectives and subjective interpretations of the research context are central concepts (Myers, 2020). This thesis studies project managers' behaviour and decision-making, which requires considering the research participants' context of their professional role. Additionally, this involves considering their personal experience and subjective perspective of the world which is aligned with interpretivism (Goldkuhl, 2012). Sterman (2000) uses the following citation from Roberts (1977) to justify the use of interpretivism in a management setting:

"If hypothesis, data and analysis lead to proof and new knowledge in science, shouldn't similar processes lead to change in organizations? The answer is obvious – NO! Organizational changes (or decisions or policies) do not instantly flow from evidence, deductive logic and mathematical optimization." (From Roberts 1977, Sterman 2000, p.26).

Since PM is a cross-industry profession, it becomes important to consider the included project managers' different backgrounds and settings. The participants' backgrounds bring their unique individual experiences, leading to creating different realities and perspectives when answering the semi-structured interview questions. Based on this, the thesis adopts a subjectivist ontological stand, meaning the research believes that reality is socially shaped and that there is more than one possible reality (Saunders et al., 2015).

The subjectivist ontology helps shape a constructivist epistemology and represents how knowledge is viewed. To follow the subjectivist ontology, it is necessary to adopt the perception that knowledge is based on contextual factors. This thought is primarily formed by the arts and humanities sciences and supports using narratives for data analysis (Silverman, 2020). The constructivist approach uses the context of the research participants and the attributes behind them and allows researchers to use qualitative methods such as interviews, case-studies, or action research (Merriam and Tisdell, 2015). It was considered to adopt a quantitative method, however, studying the phenomenon of EoC through the perspective of descriptive decision-making is preferably done through a qualitative perspective (Stingl and Geraldi, 2021).

Axiology explains the ethics and values within the research philosophy. The thesis attempts to be aware of any biased assumptions. However, it is acknowledged that being completely neutral is not possible due to the subjectivist ontology. Therefore, the research is likely to be affected by values of the researcher and the research participants (Biedenbach and Jacobsson, 2016). According to Saunders et al. (2015), the researcher needs to be reflexive and reflect continuously during the research process to question assumptions.

3.1.1 The author's personal reflections and philosophical stance

Expanding on the above sections as a researcher provides an opportunity to present the author of this thesis philosophical stance as a person and a researcher. The thesis' ontological view of subjectivism aligns with the authors view that reality is shaped through individual perceptions and experiences. This view explains that each person's understanding of the world is shaped by their unique context, beliefs, and interactions. As a researcher, it is crucial to reflect on one's personal experiences and biases throughout the research process.

Continuing with the author's epistemological standpoint, it is aligned with the thesis' constructivist stand. The author highlights the importance of social interactions and cultural contexts in shaping the understanding of knowledge and the studied phenomenon. Through the grounded theory of iterative data collection and analysis the researcher engage with the research participants and value their insights and experiences as integral to the study. This approach fosters a collaborative environment where diverse perspectives contribute to a richer, more nuanced understanding of the research topic.

During the thesis, the researcher began a career in industry in a PM context, leading to being able to observe how subjectivism and constructivism play out in practice. This enabled to understand the research and findings on a deeper level. Further on, balancing PhD research in PM with professional practice presents both challenges and rewards. Practical experience enriches academic research and provides real-world insights and examples. Conversely,

research informs practice, introducing new methodologies and theoretical perspectives that improve project outcomes. Such dual engagement fosters a deeper understanding of the complexities and dynamics within PM. It also highlights the importance of continuous learning and adaptation, as the evolving landscape of both academia and industry is navigated. The synergy between practice and research proves invaluable for professional and academic growth.

As mentioned in the introduction, the discussion of AI contains individuals' high expectations of what this technology is capable of achieving. Also mentioned, the perception of technology is constantly evolving, contemporary technology can quickly become outdated and perceptions of technology are sometimes ahead of the technology development itself (Goodwin, 2018). The fact that individuals may have a displaced relationship with AI is recognised by this PhD research. To mitigate a displaced perception of AI during the data collection, the researcher needs to be critical during data collection and data analysis. Additionally, the researcher's own potential displaced perception of AI technology is recognised. To mitigate the researcher's displaced perception of AI, the thesis follows the contemporary literature of AI in PM where AI is used to optimise project tools.

3.2 Abductive Research Approach

The three research approaches deductive, inductive, and abductive, demonstrate how theory is developed and tested. Deductive reasoning is based on testing a theory by answering a hypothesis. In contrast, inductive reasoning involves observations or experiences to develop a theory (Walliman, 2010).

This thesis adopts an abductive approach, which includes a combination of deductive and inductive. Abductive theory development collects data (inductive) to form a theory which is tested (deductive) through subsequent data (Hair et al., 2016). Abduction includes observing a phenomenon through data collection, which forms a theory and is then tested through a hypothesis (Żelechowska et al., 2020). According to Saunders et al. (2015), an inductive approach is most common among interpretative management researchers. However, the authors argue that an abductive approach is closer to what management researchers actually do and allows researchers to modify existing theories.

The choice of an abductive approach is justified when an established research field is studied in a new context (Saunders et al., 2015). This is aligned with this thesis where AI project control DSSs are applied in the context of project managers' behaviour. The abductive approach is justified through the iterative validation of the findings and the development of feedback loops.

Consequently, developing theory through an abductive approach is done by discovering themes and identifying patterns from the collected data forming theories and hypotheses (inductive), and testing these theories through additional data collection and observations (deductive).

3.3 Grounded Theory Research Strategy

To answer the main research question, the thesis adopts the strategy of Grounded Theory and the method of semi-structured qualitative interviews (Glaser and Strauss, 1967). The research question guides the choice of an iterative strategy and Grounded Theory is a systematic strategy that uses an iterative approach to analyse data and develop theory (Saunders et al., 2009). It was formularised by Glaser and Strauss (1967) (Charmaz, 2006, Locke, 2000, Saunders et al., 2009), and according to the founders it offers the social science a way to systematically analyse and interpret qualitative data to develop theory. This strategy is aligned with the interpretivist philosophy and the exploratory nature of this research topic of AI in PM (Saunders et al., 2009). It is based on the development of theory through an iterative process of data collection and engaging in the literature simultaneously (Glaser and Strauss, 2017). Essentially, this means that data is not fitted to an existing theory, instead the theory is "grounded" in the data demonstrating novel frameworks and theories.

Since the introduction of Grounded Theory, it has evolved into separate paths, known as "Glassarian" and "Straussarian", representing the founders' different views of Grounded Theory (Howard-Payne, 2016). The views argue that the researcher should enter the field free from previous assumptions and ideas by not writing an extensive literature review prior to data collection to avoid human biases (Gioia et al., 2012). However, the two views differ regarding the necessary prior knowledge of the research problem. Glaser suggests researchers avoid deep knowledge of the research topic prior to formulating a research problem and collecting data, and suggests that a more focused reading of the literature should occur when theory is emerging (Hickey, 1997). On the other hand, Strauss recommends that researchers to use knowledge of literature and previous experiences to influence the chosen research topic and the data collection to some extent (Heath and Cowley, 2004, Strauss and Corbin, 1998). According to Charmaz (2006), these views fall under objectivist Grounded Theory and introduce a constructivist view. The constructivist view adopts the view of Strauss, allowing literature and previous experiences to influence the data collection. Also, Charmaz (2006) acknowledges the need for an abductive approach and emphasises pragmatism. Constructivist Grounded Theory recognises pragmatism through the research process and the research participants in a social context. To summarise, this research adopts the constructivist view of Grounded Theory, which is aligned with the interpretive research paradigm through: 1) The assumptions of multiple

realities, 2) focuses on constructing different interpretations, and 3) aims for an interpretative understanding (Charmaz, 2008). The Grounded Theory strategy is suitable for an abductive approach through iterative testing of the developed theory and hypotheses with added collected data (Timmermans and Tavory, 2012).

3.3.1 Mental Models

Research objective number 2 states explicitly to capture mental models of project managers' using AI for project control. This is a central concept when modelling behaviour in dynamic systems (Sterman, 2000). The thesis adopts the following definition of mental models in dynamic systems:

"*...mental model of a dynamic system is a relatively enduring and accessible, but limited, internal conceptual representation of an external system whose structure maintains the perceived structure of that system*" (Doyle and Ford, 1998, p. 19).

Mental models are representations of individuals' perception of the world and social dynamic systems which become more accurate when more knowledge is gathered about the system (Morecroft, 2004). It is a useful concept to understand the underlying basis on which managers make decisions (Schaffernicht and Groesser, 2011). The concept is critical for decision theories and is suggested to reduce complexity and uncertainty during managers' decision-making (Daniel and Daniel, 2018). An effective method to visualise mental models is through feedback loops with variables and causal links through CLD modelling (Sterman, 2000, Groesser and Schaffernicht, 2012).

3.3.2 Causal Loop Diagrams

To present the empirical research, the thesis applies CLD modelling. CLD is an established method in PM research and it has been used for studying project managers' behaviour (Sterman, 2000, Ford and Lyneis, 2020, Rodrigues and Williams, 1998, Wang et al., 2020b, Sterman, 1992). It is a method that is based on demonstrating causal relationships between variables forming feedback loops (Sterman, 2000). It is part of System Dynamics modelling which includes quantitative simulations, however, this thesis only includes the qualitative application of CLD. This is justified through the research question targets behavioural theories and constructs, which can be demonstrated through CLD. It is specifically applied to demonstrate project managers' behaviour within BOR (Hämäläinen et al., 2013, Wang et al., 2020b). This method is aligned with the Grounded Theory strategy based on iterative qualitative data collection, literature analysis, and theory development (Luna-Reyes and Andersen, 2003, Kopainsky and Luna-Reyes, 2008).

The development of CLD follows four modelling steps (Kunc, 2017b, Sterman, 2000), which are presented in the section 3.3.6 Data Analysis. The modelling process is iterative where the modeller goes back and forth in the modelling steps to form the final theory and hypotheses (Sterman, 2000). The data collection follows the inductive approach, and the feedback loops comprise a hypothesis with the most significant variables representing the research phenomenon. The hypothesis is tested iteratively through a deductive approach with additional data collected from the interview participants to validate the developed loops. This is aligned with the abductive approach of the thesis.

3.3.3 Semi-Structured Interviews

The research question guides the research strategy and continues with the choice of a qualitative research method through semi-structured interviews. The exploratory nature of the research question makes semi-structured interviews a suitable method to gather research data through open-ended and semi-structured interview questions (Charmaz, 2008). The data collection is based on a data set of 22 individual research participants. The data is coded to form two separate empirical papers in Chapter 5 and Chapter 6. The data was collected through digital qualitative interviews through Microsoft Teams during the period of January 2020 to May 2022. The semi-structured interviews follow a number of pre-set questions and themes to guide the interview. The interview guide is used to support the researcher. Open-ended questions allow the participants to talk freely and follow-up questions enable the researcher to understand themes more thoroughly. The semi-structured interview themes and questions are presented in Table 3.

Table 3: Interview themes and semi-structured questions

Themes and semi-structured interview questions
1. Background
a) What is your current role?
b) What is your project management experience?
c) Are you or have you been involved with a project management membership?
d) What is your experience with Artificial Intelligence (AI)?
e) How do you use AI in your current role?
2. Project control and AI
a) In what project phases do you use AI?
b) How do you define project control?
c) How do you use AI for project control?
d) What is your experience of data in projects?
3. Project escalation
a) How do you define project escalation?
b) How do you react to project escalation?
c) What behaviour do you recognise during project escalation?

3.3.4 Sampling Interview Participants

The thesis sampled 22 participants for the research. The sampling of the interview participants is done through a non-probability approach, meaning the participants do not represent the entire population of a studied group and are selected for their specific project role and experience of using AI analysis during project control. The non-probability technique is aligned with exploratory research and includes elements of judgement, referrals and quotas (Hair et al., 2016). Saunders (2012) summarises the sampling size from the literature for semi-structured interviews to be between 5 and 35. However, most significant is that the research continues conducting interviews until saturation is achieved (Guest et al., 2006).

However, a weakness of a non-probabilistic technique is that it may attract participants without the required experience of AI technology. As mentioned in the introduction section, individuals have unproportionate expectations of AI, leading to wrong perceptions of this technology. To mitigate the risk of including participants with an incorrect perception of AI, the research uses a targeted sampling strategy where the included project managers are chosen based on their project role within the project control process and experience in using AI technology during this process (Saunders et al., 2015). This was ensured by asking the participants questions regarding their roles and AI experience. According to Morse (2010), it is necessary to set criteria for the interview participants and expose the participants to the research phenomenon. This differs from quantitative research in which the sample frame is suggested to be representative of the whole sample population. Qualitative research may therefore recruit participants purposively. The chosen participants had experience interpreting the project progress directly from an AI DSS or having the results interpreted by a data analyst team member.

Additionally, for a hyped topic such as AI, the participants are expected to be interested in the research topic. This is known as voluntary sampling and the participants must participate at their own will (Saunders, 2012). The mentioned sampling techniques have limitations since the participants may be biased towards the topic, e.g. optimistic about AI's abilities or pessimistic towards AI due to poor previous AI experiences. Such biases need to be mitigated by carefully analysing the interview participants and the context of the participants' answers during the interviews and the data analysis. Other criticism towards a non-probability technique is the inability of the findings to be representative of the entire sample population and cannot be generalised to the whole target population (Hair et al., 2016). The interview participant demographics are presented in Table 4. The table demonstrates the most recent project context of the participants with the headers years of experience, project industry, organisation size, project type and project budget.

Table 4: Interview participant demographics

Demographics		**Total Participants 22**
Years of Experience	< 5 years	6
	5 – 10 years	5
	10 + years	11
Project Industry	Automotive industry	4
	Aviation industry	4
	Construction industry	6
	IT industry	8
Organisation size	< 10	3
	10 – 50	8
	51 – 100	5
	100 <	6
Project type	Infrastructure project	8
	Production project	6
	Software development project	5
	Supply chain	3
Project Budget	< £499,999	12
	£500,000 – £9,999,999	10
Type of AI used (Huang & Rust, 2018)	Rule-based expert system (explainable AI)	0
	Analytical AI through machine learning (black box)	7
	Combination of expert systems and machine learning	15

3.3.5 Cross-industry Sampling

The thesis targets project managers in the control phase in a cross-industry environment. This is justified through previous studies have focused on the project control process for multiple industries (Ford and Lyneis, 2020, Lyneis and Ford, 2007). Additional justification for a cross-industry research is Song (2010) who demonstrated the project control process see similarities across industries when using tools such as Earned Value Management.

The non-probability approach and the purposive sampling enable to select appropriate interview participants based on their PM background and experience in AI technology. Having participants with the appropriate background is key for this research since it targets a cross-industry project environment of the control process. Meaning the participants are from different industries with the nominator of having a role in the project control process with experience of AI technology. The participants' industry background is spread across automotive, aviation, construction and IT industry. The behaviours discovered in the interviews is applicable to project managers' behaviour in a cross-industry context.

3.3.6 Data Analysis

The coding process follows the Grounded Theory research strategy of an iterative process and interview data is collected until saturation is reached (Mason, 2010). Finding a balance in the data collection is important where too much data may have a negative effect on the research process as it may delay the research schedule, and the amount of data may be overwhelming. On the other hand, not enough data may not provide a rigorous research process (Morse, 2010). The thesis was able to determine that saturation was reached when the comparison of new data with previous data concluded that no new findings or information emerged. The iterative process enabled to conduct several interviews with the same participants and compare previous data with new data from multiple participants. The process required thorough data analysis to ensure the research findings followed the principles of the Grounded Theory strategy and careful consideration of the collected data amount. The interviews were held during the period of January 2020 until May 2022, which allowed to rigorously and carefully analyse the data while collecting further data to ensure saturation was reached.

Sterman (2000) expands on the data collection for CLD modelling and highlights the critical iterative approach. He suggests that it can be seen as a creative process. CLDs allow the modelling of holistic social systems from various macro-level perspectives where the research question and the research context set the boundary of the CLD. Additionally, deciding on the model boundary is steered by including the most significant variables in the final CLD (ibid). The full coding analysis of the empirical research papers is found in the research papers in Table 15

and Table 17 with the final CLD models in Figure 13 and Figure 16. An example of adjustments that occurred during the iterative process is names of the variables and the number of included variables in a causal loop. Such an example is the variable “willingness to take corrective action” which was originally named “motivation to take action”. However, during iterative data collection and refinement of variables “willingness to take corrective action” was chosen as most representative of the participants’ decision process.

The data analysis adopts the coding steps of: open, axial, and selective coding (Glaser and Strauss, 1967). Combining Grounded Theory and CLD modelling is a justified process (Luna-Reyes and Andersen, 2003). The coding steps are combined with the four modelling steps of CLD development (Kunc, 2017b, Sterman, 2000): 1) Identifying variables from the interview data through first-order open coding. 2) Identifying the direction of causality between variables through second-order axial coding. The variables are refined while exploring relationships between them to show more depth of understanding. Meanwhile iteratively conducting further interviews (Strauss and Corbin, 1998). 3) Further axial coding involves identifying casual chains and the polarities of the variables. 4) The fourth step involves selective coding, where core variables make up feedback loops and the dynamics in the CLD are demonstrated. The iterative process includes validating the findings with the participants (Sterman, 2000). An example of the thesis’ CLD modelling is presented below in Figure 7, Figure 8 and Figure 9. The example demonstrates the development of the feedback loop “Trust in AI”. The loop is presented in more detail in Chapter 5, Figure 12. The loop is developed through interview data and consists of four variables with positive causal links.

Step 1 and open coding identifies the variables of “project data generation” and “trust in AI model” through brackets in the below interview citations. Further on, axial coding in steps 2 and 3 identifies the causal link direction and assigns the positive polarity. The causal link direction and polarity are identified through the citations explaining that the use new data increases the trust in the AI model. The mentioned variables and the causal link is demonstrated in Figure 7.

“As the project continues, the project generates new data [project data generation] and we can use the updated data to improve our model. We are then also able to improve the trust in the model [trust in AI model].” – Participant 4

“I want as much new data as possible in the AI model, the data used for planning is important, but using the new data [project data generation] makes me trust we use the most relevant data [trust in AI model].” – Participant 11

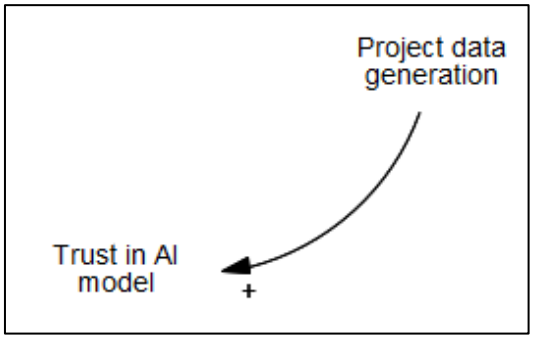

Figure 7: Causal link of “project data generation” and “trust in AI model”

The above steps are repeated through further open and axial coding. The below interview citations demonstrate that the variable “trust in AI model” have an increasing effect on “willingness to take corrective action”. The causal link and polarity is seen in Figure 8.

“… the more trust I will have in the model [trust in AI model] and I will be willing to act on the AI analysis [willingness to take corrective action].” – Participant 11

“If I trust the AI model [trust in AI model] and it recommends me to look at something, then I will be willing to follow its suggestion [willingness to take corrective action].” – Participant 3

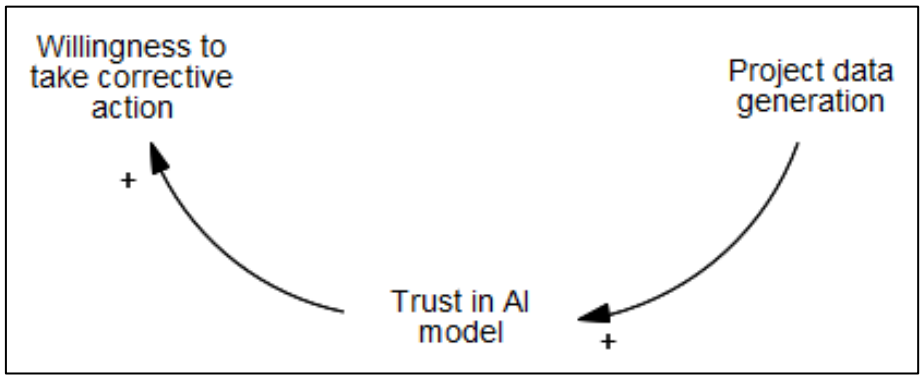

Figure 8: Causal links of “project data generation”, “trust in AI model”, and “willingness to take corrective action”

Moving on, the final step of CLD modelling through selective coding is demonstrated in the below citations. The causal links of “willingness to take corrective action”, “rework discovery”, and “project data generation” are added to form a feedback loop. The loop is presented in Figure 9 and demonstrates that all causal links have positive polarities and form a reinforcing feedback loop. The validation of the data analysis follows Grounded Theory strategy and is iteratively validated by several research participants.

“If I decide to follow the AI [willingness to take corrective action], I see what the issue is [rework discovery], at the same time the AI model learns constantly from the identified delays [project data generation] and will improve for next time.” – Participant 18

"When I act on the warning sign [willingness to take corrective action], I then analyse what is required to do, where is the missing link and what do we need to do to fix it [rework discovery]. This generates more data [project data generation] for the AI model to learn from." – Participant 12

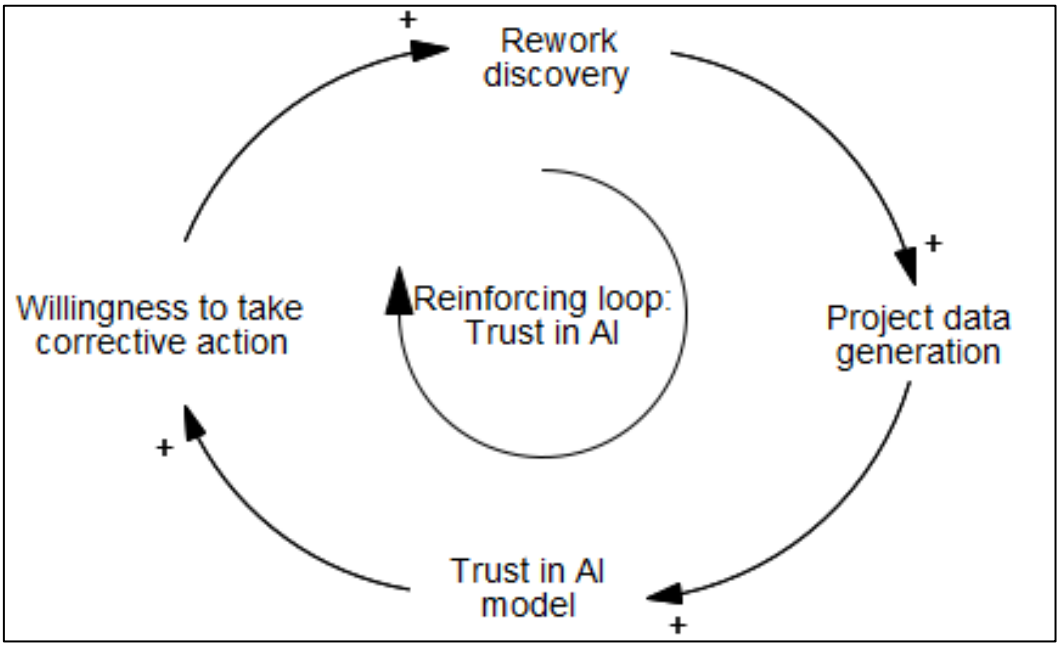

Figure 9: Causal links of "project data generation", "trust in AI model", "willingness to take corrective action", and "rework discovery"

3.4 Research Ethics

It is significant for any research to follow the ethics regulations from an early stage (Oliver, 2010). Israel and Hay (2006) suggest some social scientists claim regulations for seeking research ethics approval hinder conducting research, however, the mentioned researchers emphasise that considering ethics provides a more robust research process. Prior to the qualitative interviews, the author completed an ethics submission form to the University of Southampton through ERGOII. This submission was approved by the research committee and has ERGO number 53466, see Appendix B for the ethics form. Although the research does not ask for any personal or sensitive information from the interview participants, the research acknowledges the data regulations when conducting qualitative research. A data management plan was set where all the data was anonymised. To protect the interview participants, a consent form is signed by the interviewees and the researcher prior to the interview. All the data collected was anonymised when transcribed.

3.5 Summary of Research Methods

To summarise the research methodology chapter, the thesis adopts an interpretive philosophy with a subjective ontology and constructivist epistemology. An abductive research approach is chosen by combining an inductive process of theory development and deductively testing the theory with subsequent data. This strategy of Grounded Theory guides the data analysis of semi-structured qualitative interviews and the findings are presented through CLD models.

The thesis presented the introduction with the research question and how it answers the gap in studying project managers' behaviour and decision-making when using AI-based DSS for project control analysis. The introduction demonstrated the key research topics, followed by the theoretical framework of project control, analytical AI, and BOR through Descriptive Decision Theory. The framework of project decision-making demonstrated the area of heuristics in PM and that the thesis adopts HB when studying managers' behaviour through BOR behaviour with models. The research methods enable the thesis to contribute to AI in PM through BOR. To this point, the thesis presents the introductory chapters, which set up the context of the research. The following chapter presents the SLR which represents the first phase of the thesis. The output of this paper includes the identified research gap in which the empirical research formulated the main research question.

Chapter 4 First Research Paper

Title: Mapping the Literature of Project Management and Artificial Intelligence: A Systematic Literature Review

Abstract

Artificial intelligence (AI) has the potential to significantly enhance project management (PM) processes. Research on AI in PM has gained increasing attention from the project community. However, the literature is disjointed and lacks a clear research agenda. Through a systematic literature review, we analysed a total of 2,690 papers and 63 papers were included for final review to identify transitional elements from conceptual-based research, contemporary methods that optimise project knowledge areas using advanced AI models, and empirical research on project managers' perception of AI. Based on this analysis, we outline a research agenda underpinning AI's role in assisting project managers' decision-making. That includes the application of AI to optimise project areas through current Decision Support Systems, a deeper understanding of project data, and improved collaboration between researchers and practitioners.

Keywords: artificial intelligence, decision support systems, project control, project knowledge areas, project management, project planning, project scheduling, stakeholder management, project performance

4.1 Introduction

Artificial intelligence (AI) is increasingly being studied in various business fields, including finance, retail, and marketing (Cubric, 2020; Loureiro et al., 2021). Previous attempts to review the literature on the use of AI in PM have included the application of AI prediction tools for project success (Martínez & Fernández-Rodríguez, 2015), deep learning within the construction industry (Akinosho et al., 2020; Xiao et al., 2018), and machine learning in project management (PM) (Chennouk et al., 2020). Recent reviews focus on entrepreneurial projects (Kiani, 2024a) and targets specific keywords in the search protocol (Nenni et al., 2024a). Further interest in AI is shown through reviews studying AI through algorithmic decision-making (Kordzadeh and Ghasemaghaei, 2022) and project data analytics (Shen et al., 2024). Further, AI algorithms have gained significant attention in the context of enhancing Decision Support Systems (DSS)

(Cubric, 2020), and optimising operational research (OR) through quantitative modelling (De Bock et al., 2024, Gupta et al., 2021, Kobbacy and Vadera, 2011).

Implementing AI in DSSs provides autonomy and flexibility (Kobbacy and Vadera, 2011), and enables DSSs to be used for real-time decision-making (Gupta et al., 2022). They allow organisations to quickly identify potential solutions and make informed decisions with greater accuracy than manual techniques (Hazır, 2015). Additionally, DSSs can help reduce the risk associated with complex decision-making processes by providing accurate information about possible outcomes of different options (Shim et al., 2002). Essentially, DSSs increase the rationalisation of decisions and reduce human subjectivity (Phillips-Wren et al., 2019). Conversely, poor project decision-making has a negative impact on the cost and duration of projects, often leading to their ultimate failure (Stingl and Geraldi, 2017a). To illustrate this point, research conducted by Flyvbjerg et al. (2005) suggests that 9 out of 10 megaprojects experience a 50% cost overrun, partly related to adversely biased decision-making. Overrun in information systems projects is also highlighted by Benschop et al. (2020b) to be a significant reason for project failure. It is particularly pertinent that AI has the potential to significantly improve PM processes through real-time decision-making in challenging areas of project planning, resource scheduling, and stakeholder management (Pellerin and Perrier, 2019).

While AI is examined in management contexts, it has received limited attention in project research. A review of two leading PM journals (‘Project Management Journal‘ and ‘International Journal of Project Management‘) reveals that only a handful of published papers include ‘artificial intelligence‘ in the title, abstract, or keywords. These papers range from early literature discussing the use of expert systems in construction projects (Arditi & Patel, 1989) to more recent publications exploring AI expectations among project managers (Holzmann et al., 2022) and the use of data analytics and AI in megaprojects (Wijayasekera et al., 2022). The limited number of papers on AI in PM journals reflects a disparity between the need to research this field further and the number of published research papers.

Furthermore, prior studies focus on explicit AI techniques and applications in specific project areas, but none provide a comprehensive overview of the themes, trends, and future research directions for AI in PM. To address this knowledge gap, we conduct a Systematic Literature Review (SLR) to provide a comprehensive overview of the existing research on the use of AI in PM. We follow the SLR method of Tranfield et al. (2003), which is well-established in business and management fields (Snyder, 2019). Our review aims to answer the following questions:

1) What themes define the project management and AI literature?

2) What trends can be identified in the project management and AI literature?

3) What future research agenda can be identified from the project management and AI literature?

We aim to provide a research agenda for the PM community as a reference point for applying AI in PM. The remainder of our paper is structured as follows: after the theoretical background, we present the SLR methodology and the detailed search protocol that led to the inclusion of 63 articles in the final review. We then present our findings and discuss their implications, proposing a future research agenda. We conclude with a summary of our main contributions.

4.2 Theoretical Background

Our review relies on the theoretical background of AI embedded in project DSSs (Bilgin et al., 2023). Herbert Simon and his colleagues can be seen as the founders of contemporary decision-making theory for humans and DSSs (Newell and Simon, 1961, Newell and Simon, 1972), and contemporary decision theories can be expanded to DSSs (Arnott and Gao, 2019). In recent decades, the increase in computer power, IT availability, and visualisation of project data has enabled the use of AI in PM (Stingl and Geraldi, 2021, Killen et al., 2020).

Some project DSSs are well-established among practitioners, such as MS Project, however the level of AI analytical ability varies. Our paper adopts the following definition of DSS: "*The user is expected to interact with the system in some way to provide input or data, make choice about processing, interpret results, or come to a decision. In short, the system should help the decision maker think rationally*." (Phillips-Wren et al. 2019, p. 63). Based on this definition, a DSS can be used as an IT decision system to assist project managers' decision-making. Project DSSs have seen improvements in quantitative analysis of management activities through the field of OR, advanced mathematic modelling, and AI technology (Gupta et al., 2022). It is suggested to categorise AI DSSs into two categories, the first uses rule-based expert systems, and the second involves advanced AI models based on neural networks (NN), genetic algorithms (GA), and fuzzy logic (FL) (Turban et al., 2005).

When facing structured or unstructured problems, AI models use different heuristic techniques (Pellerin et al., 2020). Some AI models offer approximate heuristic solutions (Akinci and Sadler-Smith, 2012), while others are more precise in their analysis (Mousavi and Gigerenzer, 2014). For example, project scheduling is a complex task involving scheduling limited resources while minimising project cost and duration (Herroelen, 2005, Padalkar and Gopinath, 2016). Optimisation of project areas is closely related to the fields of OR and PM have seen large influence from this field (Tavares, 2002, Kanakaris et al., 2019). The main objective for OR is problem-solving through optimisation (Tavares, 2002). It is suggested that human-centred

project areas such as managing team members and knowledge management will have the least effect from AI and optimisation (Fridgeirsson et al., 2023, Holzmann et al., 2022).

The complexity of scheduling makes it suitable to apply less deterministic solutions, known as heuristic algorithms (Hartmann and Briskorn, 2022, Vega-Velázquez et al., 2018). Hartmann and Briskorn (2010) propose the AI models of NN, GA, and FL for this purpose (Pellerin et al., 2020). NN is based on several layers of connected nodes, where the input data is weighted based on specific criteria. As the information passes through the layers of the NN model, the model recognises patterns in the data and provides an output (Hecht-Nielsen, 1992, Bishop, 1995, Siqueira, 1999, Chaphalkar et al., 2015, Abiodun et al., 2018, Hsu et al., 2021). GA on the other hand follows the approach of 'the survival of the fittest', where the model emphasises natural selection and searches for the best solution based on specific parameters (Bettemir and Sonmez, 2015, Chou et al., 2014, Fang and Ng, 2019, Holland, 1992, Montoya-Torres et al., 2010). Further on, FL allows an approximate solution based on incomplete, 'fuzzy' information, which represents real-world projects more accurately based on projects' characteristics of having limited and imperfect information (Klir and Yuan, 1995, Zadeh, 1988, Eghbali-Zarch et al., 2022, Cheng and Roy, 2011, Naeni et al., 2011, Zhou and Zou, 2021). Less complex problems benefit from deterministic solutions, such as decision trees. (Faezy Razi and Hooman Shariat, 2017, Xie et al., 2024).

Moving forward, we present our paper on the premise that AI has the potential to enhance project DSSs and assist project managers in their decision-making. To understand previous contributions in this field, it is significant to map the literature of AI in PM through a SLR to identify a research agenda for the PM community.

4.3 Methodology

We adopted the SLR approach by Tranfield et al. (2003), which includes the stages of planning, conducting, and reporting. This method is justified by the high number of researchers applying this approach (Chaudhary et al., 2021, Denicol et al., 2020, Kapoor et al., 2021, Lappi et al., 2018). Moreover, this method is an established approach when conducting a SLR within the field of business and management (Snyder, 2019). The SLR method ensures a transparent review of previously published research (Petticrew and Roberts, 2008, Snyder, 2019). It also provides a replicable and unbiased method to review a specific section of the literature (Siddaway, 2014, Snyder, 2019). The SLR method by Tranfield et al. (2003) involves: 1) The planning stage, which sets the search protocol based on inclusion and exclusion criteria. 2) The conducting stage, where the inclusion and exclusion criteria are executed, for which we used an Excel document to keep a record of all papers. The structured technique defines the SLR and differentiates the

method from a traditional literature review (Denyer and Tranfield, 2009). 3) The reporting stage represents the actual results section (Tranfield et al., 2003).

4.3.1 Planning Stage

According to Tranfield et al. (2003), the search process is iterative and offers a degree of flexibility, and detailed planning of the search protocol is not recommended. Further on, it is essential to develop clear research questions for a SLR since the questions set the direction of the search and define its scope (Denyer and Tranfield, 2009). A formal search protocol was developed containing the inclusion and exclusion criteria. The purpose of the protocol is to provide a transparent view of the search process, and it enables to maintain consistency throughout the review (Tranfield et al., 2003).

During the planning stage we identified the need for a review, prepared a review proposal, and developed a search protocol (Tranfield et al., 2003). Aligned with this method, we held informal discussions with project researchers and professionals to identify the relevance of such a review. It was concluded that the terms ‘project management’ and ‘artificial intelligence’ should be in the articles’ title, abstract, and or keywords. Deciding the exact search string required further analysis. During this stage it became clear that the term ‘project’ is used inconsistently in management literature. The multifaceted nature of projects in management research leads to the term ‘project’ is often referring to a specific piece of work without being relevant to PM. This leads to management researchers using the terms ‘project(s)’, ‘project manager(s)’, or ‘project management’ in a wide context. Discussions were held regarding the relevance of the keywords and the search scope. It was concluded that a research article can be highly relevant to PM literature when discussing the context of ‘project managers’. Conversely, another article can be irrelevant even though the term ‘project’ is used in the abstract, as this term may only refer to a specific set of activities. Based on this reasoning, we decided that the final search string should minimise the non-PM related literature. Hence, the chosen search terms specified ‘project management’ and ‘artificial intelligence’ rather than the term ‘project’.

Additionally, we discovered that the term ‘artificial intelligence’ is used in different business contexts. We found that management researchers study AI from different perspectives, including its use and implications for management. Further, AI is commonly referred to in software engineering and computer science management. We did not search specifically for the latter two fields. In summary, we used the exact keywords ‘project management’ and ‘artificial intelligence’ with additional search filters. The search protocol with the search strings, as well as the inclusion and exclusion criteria are presented in Figure 10.

4.3.2 Conducting Stage

We carried out the search as far back as the databases allowed until July 2024. The SLR process was conducted according to the following steps: The first step involved deciding the databases included in the search: Scopus, Emerald, and SAGE. This is justified through Scopus is suggested to be the largest academic database (Mongeon and Paul-Hus, 2016). Further on, after trial searches we found that the databases Emerald and SAGE complement the literature without overlapping in duplicate search hits. The keywords 'project management' and 'artificial intelligence' with complementing search filters resulted in 530 search hits on Scopus, 1791 on Emerald, and 369 on SAGE. Emerald and SAGE databases do not offer as many filters as Scopus, leading to a shorter search string presented in Figure 10. All three databases resulted in 2,690 papers for further review in step 1. This step involved screening for duplicates. A total of 6 duplicates were removed (three from Emerald and three from SAGE), leaving 2,684 articles to the next step.

In step 2, we removed another 51 articles based on non-available abstracts on the databases or not having access to the papers through the University of Southampton, UK, library system. This led us to move forward in step 3 with 2,633 papers. During this step we followed the search protocol by identifying all papers with the exact words 'project management' and 'artificial intelligence' in either the title, abstract, or keywords. After this screening process, the protocol excluded 2,510 articles.

Step 4 involved reading the remaining 123 papers in full to decide their relevance to PM and AI. This was an important step since an article may have passed previous inclusion steps irrelevant to PM and AI. This reoccurred in papers studying software development, computer science, and OR. An example of such papers is Ormerod (2021) studying AI and OR where PM is included in the abstract and AI is included in the title and keywords. However, the paper's focus is not explicitly on AI in PM. Other examples of articles with limited PM scope were excluded based on their focus on AI in healthcare, agriculture, or engineering. Additionally, to scope our search to focus primarily on research papers, we excluded other literature reviews, resulting in removing 60 papers in this step. The final step included a qualitative thematic analysis of the final 63 papers. Adopting a thematic analysis enabled to identify and analyse themes in the reviewed papers to answer the research questions. The thematic analysis was documented in an excel file and followed an inductive coding process (Breit and Volkmann, 2024). Through the coding process we identified themes of the AI in PM literature.

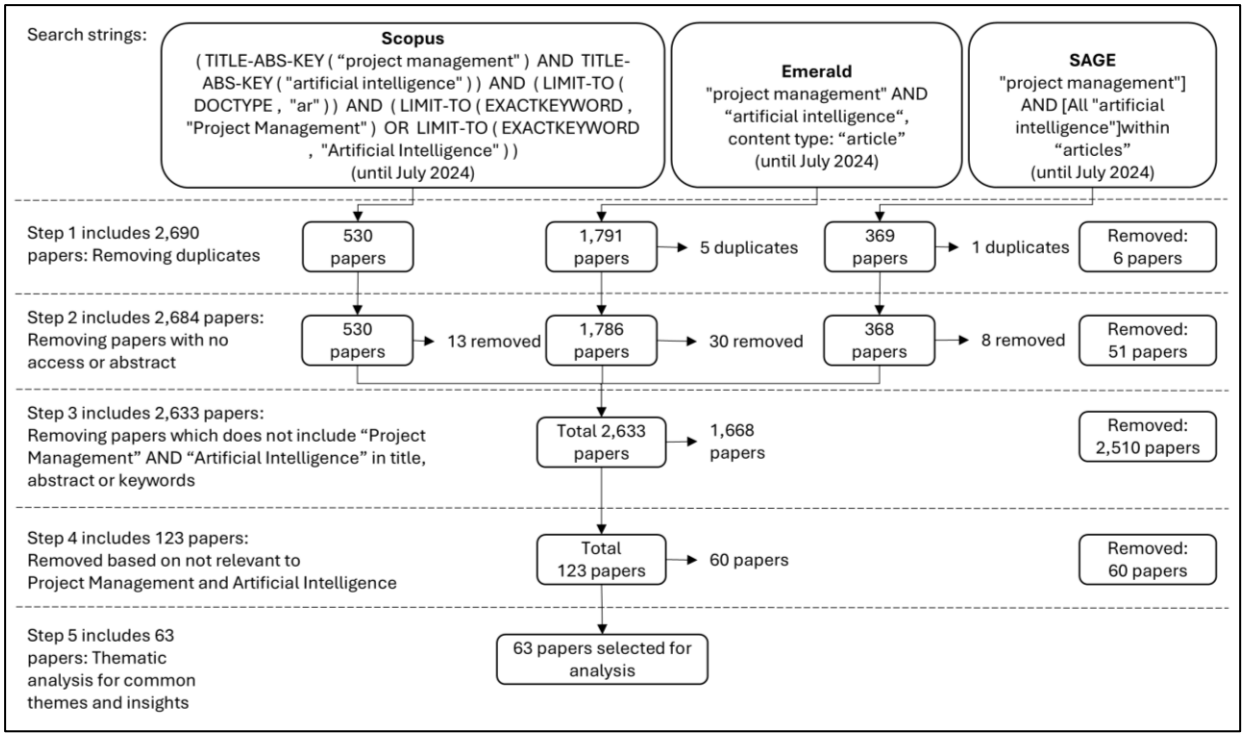

Figure 10. Search protocol

4.4 Review Findings

Following the planning and conducting stages, we present our review findings in the reporting phase (Tranfield et al., 2003). Our thematic analysis of the 63 papers categorised the literature into four methodological themes: 1) conceptual papers with a theoretical discussion of the challenges and the potential of applying AI in project management, 2) using a single AI model to optimise a project knowledge area, 3) using a combination of AI models to form a hybrid AI model to optimise a project knowledge area, and 4) conducting empirical research to study project practitioners' perception of AI. Additionally, we identified project knowledge areas and specific project industries where AI is applied.

4.4.1 Conceptual Papers

Project researchers have held conceptual discussions about AI in project DSSs for over three decades. Niederman (2021)summarises the contemporary discussion by recognising that AI is seen through opportunistic and pessimistic perspectives. The pessimistic view suggests AI may replace project managers, whereas the opportunistic focuses on AI enhancing project managers' decision-making through improved analytical DSS. Further on, it is suggested that project environments are often too complex for managers' decision-making capabilities, and AI DSSs can assist with project managers' limitations surrounding 'bounded rationality' (Sarma, 1994). Early research suggest that when DSSs lack an effective AI analysis, the systems tend to

have a passive role when supporting project managers (Roth and Hendrickson, 1991). To overcome this challenge, it is necessary to include heuristic AI models (Noronha and Sarma, 1991). Additionally, early conceptual discussion proposed that effective project DSSs should be based on the viability and purpose of the project, as well as the ability to optimise resources and initiate corrective actions in a timely manner (Sarma, 1994).

Further on, the contemporary discussion includes critical success factors for AI in PM. Niederman (2021) suggests including AI for: project selection, updating work packages and project plans, improving early warning signs, and applying real project data for testing AI systems. Li et al. (2021) suggest implementing an AI office in construction projects to act as a central hub between stakeholders. This would improve project stakeholder management and reduce stakeholder conflicts. See Table 5 for the contemporary conceptual papers from the review. Moving on from the conceptual discussion, the next section demonstrates the literature on applying AI models to optimise project knowledge areas.

Table 5: Conceptual Papers – Contemporary publications

Publications	Research Context	Contributions
(Li et al., 2021)	Implement an 'AI office' for construction stakeholders.	The findings suggest construction projects can benefit from an AI office gathering and analysing data. This can lead to improved stakeholder management.
(Nazarenko et al., 2022)	Using AI for business road mapping.	The authors suggest AI can be used for business road mapping by overcoming human bias and pre-assumptions during project planning.
(Niederman, 2021)	The study focuses on the potential disruption of AI in project management.	Contributions include: 1) Project managers need AI knowledge but not advanced AI skills. 2) Project software will likely become more advanced through AI and more cost effective. 3) Managers working with AI cannot ignore to develop project management skills.

4.4.2 Optimisation through Individual AI Models

The second methodological theme involves optimising project knowledge areas through AI methods. A contemporary research topic is to study how generative AI models based on Large Language Models can be applied to different knowledge areas, such as identifying risk failures (Strang and Vajjhala, 2023), risk management (Nyqvist et al., 2024), and software development (Bahi et al., 2024). See Table 6 for the most contemporary papers using single AI models. Xu and Lin (2016) propose optimising human-centred, data-poor, and non-traditional quantitative project areas, such as stakeholder management through heuristic AI methods. Other researchers call this decision-making environment 'grey situation decision-making' (Zhou and Zou, 2021). It is suggested that the heuristic method of fuzzy-AI techniques be applied for this purpose since it can deal with uncertain attributes and represent 'real-world problems' (Xu and Lin, 2016).

Table 6: Individual AI Model Papers – Contemporary publications

Publications	Research Context	Contributions
(Aljaz, 2024)	Applied ChatGPT within "Theory of Constraints".	The paper suggests ChatGPT can potentially improve project decision-making through the theory of constraints.
(Bahi et al., 2024)	Applied ChatGPT for agile project management and support during software development.	The authors propose generative AI will have large implications for software project development within e.g. role definition, requirement mgt., change resistance, and effort estimation.
(Greeshma & Edayadiyil, 2022)	Image recognition is used for control construction projects.	The authors suggest applying image processing methods to monitor construction project progress, this can have significant implications for current manual methods.
(Karnouskos, 2024)	Applied different generative large language models for project management purposes.	The paper suggests generative AI models are able to answer PM certificate exam questions, managers and AI are in close partnerships, and PM certificates should include assessments of how managers apply generative AI for project purposes.
(Lung and Wang, 2023)	Applied AI for construction projects and image recognition.	The contribution includes optimised image recognition on project construction sites based on neural networks.
(Nyqvist et al., 2024)	Applied ChatGPT for risk management.	The paper evaluated the performance of generative AI for risk management. The authors suggest AI and managers collaborate.
(Strang and Vajjhala, 2023)	A study using AI models to identify project failure indicators.	The authors suggest that project managers' experience and the potential to outsource project managers are the two most significant sources of project failure.

Another heuristic AI model, NN, is applied when studying the investment risk of IT start-up projects (Viktor et al., 2021). The findings suggest that the total investment amount is not a key factor impacting the overall project risk. Instead, key factors are the project characteristics and the external environment of the start-up project that influence the overall risks. Further on, the same AI technique is applied for automation of monitoring and control in construction projects (Greeshma and Edayadiyil, 2022). In this example, the NN model is applied for image processing to detect faults in construction walls, removing the manual handling of this task. Additionally, NN is used to minimise time and cost when developing construction materials (Varouqa, 2021). Inconsistency during planning and design activities in construction projects motivates combining AI techniques with building information modelling (BIM) (Novembri and Rossini, 2020).

The previously mentioned AI model GA demonstrates effective optimisation of road construction sites and provides more efficient workflow and reduced traffic delays (Amândio et al., 2021). Reducing traffic delays is an example of how AI optimisation can positively impact external stakeholders and end users. The same study provided a user-friendly interface of the GA technique when combined with the MS Project software. Optimising the project control technique of Earned Value Management through an AI model is done by Wauters and Vanhoucke (2014). The authors claim the AI model outperforms the traditional technique of Earned Value. However, the researchers point out that the AI model depends on training data

sets. They conclude that the performance of the AI model will be insufficient if the training data does not represent the real-life project dataset.

4.4.3 Optimisation through Hybrid AI Models

When combining several individual AI models, researchers can utilise the strengths of the separate AI techniques and build on the benefits of each AI model. One example combines two models to study the risks of construction project delays and uses the term 'hybrid AI' for this purpose (Yaseen et al., 2020). The study showed better results using a hybrid model rather than applying the AI models individually and suggests that the combined hybrid method should be adapted to the specific problem. This is an effective method when solving problems in a complex project environment. An example of such complexity is stakeholder litigations, where a hybrid AI model is applied to solve stakeholder conflicts (Zheng et al., 2021). Additionally, optimising the prediction of stakeholder conflicts can provide a proactive early warning DSS (Chou et al., 2014). The authors suggest a hybrid model can assist complex decision-making when reviewing stakeholder contracts, save litigation costs, and reduce further project delays. Recent studies apply hybrid models to risk evaluation (Chang and Liang, 2023), project cost and duration (Darko et al., 2023), and to predict project success (Kim and Jang, 2023). Two NN models are used for forecasting and scheduling the construction process for a renewable energy project (Liu and Hao, 2021). The model performed forecasts ahead of time compared with traditional forecast methods. The construction industry is studied through a NN model for risk analysis of construction stakeholders' contract clauses. The mentioned model is suggested to be used throughout the project life cycle and improves the consistency of risk management (Choi et al., 2021). For the contemporary hybrid papers, see Table 7.

Some researchers use hybrid models to enhance traditional project DSSs. For example, a hybrid model is used to measure earned value metrics by analysing data from a multiple project environment (Hajiali et al., 2020). The authors argue that using data from multiple projects can outperform the analysis of individual project datasets. Additional hybrid models have shown positive results when compared to earned value (Wauters and Vanhoucke, 2016, Wauters and Vanhoucke, 2017).

Table 7: Hybrid AI Model Papers – Contemporary publications

Publications	Research Context	Contributions
(Chang and Liang, 2023)	The research optimises risk evaluation.	An optimised AI risk evaluation model for agriculture projects.
(Darko et al., 2023)	Studied AI models to improve cost and duration for construction projects.	Applied the model on green building projects to increase the probability of successful sustainability projects.

Publications	Research Context	Contributions
(Kim and Jang, 2023)	The research applied AI models to predict successful R&D projects.	The paper suggests that project funding is significant when classifying R&D project success.
(Uddin et al., 2022)	AI models are used to improve construction project cost overruns.	The authors propose a data-driven framework for project management through AI models.

4.4.4 Empirical Papers

Our review shows how project researchers study AI in PM through a conceptual discussion, and how AI can optimise project areas through specific individual AI models, or hybrid AI models. These approaches enable project researchers to perform empirical studies of AI's impact on PM. The empirical research papers are based on either quantitative surveys or qualitative interviews to study the project practitioners' perception of AI and its use in PM. Contemporary empirical papers are seen in Table 8, including Barcaui and Monat (2023) who suggest utilising generative AI to automate managers' tasks and Tominc et al. (2024) studying the incentives for small and medium sized enterprises to include AI in their daily PM operations.

The findings suggest that the quantifiable areas of project cost, schedule, and risks are most affected by AI in the near future. While human-centered areas of managing and leading a team, based on soft skills, are least affected (Fridgeirsson et al., 2023). This can be explained through project cost, schedule, and risks generating quantifiable datasets that enable project AI DSS to optimise these areas. While knowledge areas based on soft skills, such as leadership and emotional intelligence, generally lack quantitative data. These findings are confirmed by other studies suggesting that AI is most relevant for project scheduling, scope, costs, control, risks, and allocating project team members (Holzmann et al., 2022). Further on, managing teams and team knowledge management are ranked as having low relevance for AI (ibid). Similar results are seen through semi-structured interviews with project managers from the construction industry suggesting that AI is less likely to replace project managers' role in managing projects (Kumar et al., 2021).

Further on, considering the user of AI-based DSSs should be based on safety measures, accountability, interaction, and process efficiency (Farrow, 2021). Other empirical researchers conclude that AI is currently applied at a limited scale in PM, as well as there is a gap between the available AI DSSs and the expectations of AI, leading to unsatisfied users. Additionally, practitioners state challenges for using AI include lack of project data, lack of trust to use AI, limited knowledge of AI among practitioners, and high costs with uncertain return of investment (Wachnik, 2022, Fridgeirsson et al., 2023).

Table 8: Empirical Papers – Contemporary publications

Publications	Research Context	Benefits for AI in PM	Challenges for AI in PM
(Barcaui and Monat, 2023)	A comparative study between generative AI and project managers in project plan development.	Large potential for synergies when combining generative AI and human project managers.	Challenges include identifying weaknesses in generative AI outputs.
(Bozorgzadeh and Umar, 2023)	Studies how computer vision impacts construction projects.	Computer vision has large potential for progress monitoring of construction projects.	Lack of competence among practitioners to apply this technology.
(Cancer et al., 2023)	A survey studying which project industries AI can support.	Industries with professional, scientific, and technical characteristics have the highest potential for AI support.	The variance of potential in project industries may result in an unequal level of AI support in project industries.
(Fridgeirsson et al., 2023)	A study based on how AI may affect PMI knowledge areas.	It suggests that AI will affect scheduling, cost management, and risk management the most.	It becomes a challenge to utilise AI in the less integrated knowledge areas.
(Mishra et al., 2023)	The paper discusses how AI can support IT projects.	Suggests AI to be used for analytics during the planning and execution phase.	Challenges include data requirements for analytical AI models.
(Tominc et al., 2023)	Studies how agile PM can increase AI and project success.	Suggests a model for organisations to adopt for improved agile practices.	Failing to implement agile practices may cause less successful projects and non-competitive organisations.
(Tominc et al., 2024)	The paper studies small and medium enterprises' use of AI for project management.	The paper suggests AI may be used to improve decision-making and automate routine tasks.	SMEs are suggested to implement strategies to enhance AI adoption.

4.4.5 Defining Trends in AI and Project Management Literature

In our analysis we identify four methodological themes. Additionally, we demonstrate that the literature has followed specific trends throughout the years. Early papers from the 1990's consisted of conceptual papers, whereas contemporary publications are based on optimising project areas through individual or hybrid AI models, see Table 9: Identified methodological themes. Optimisation through AI models represents 57% of the reviewed papers. Further on, more than half of the papers have been published since year 2021 which demonstrates the contemporary interest for AI in PM. A further contemporary trend is the interest in empirical research. However, only two out of thirteen empirical articles study a specific knowledge area, which indicates that empirical project researchers aim for an overall understanding of the profession rather than understanding a specific knowledge area. The recent increase in empirical research provides an insight in project researchers awareness of the importance of understanding AI in PM from an empirical perspective. We find several papers studying generative AI models, and we assume the increased accessibility of AI tools, e.g. Chat GPT, is a

reason for this. Further on, the construction industry is most studied through 44% of all papers, followed by projects in a cross-industry environment, see Table 10.

Table 9: Identified methodological themes in SLR

Year	Conceptual papers	Single AI model	Hybrid AI model	Empirical papers	Tot:
1991 – 1995	5	2			7
1996 – 2000	1	1			2
2001 – 2005	1	1	1		3
2006 – 2010		1	3		4
2011 – 2015		3	2		5
2016 – 2020		2	4		6
2021 – July 2024	3	13	7	13	36
Total:	10	23	17	13	63
Percentage:	16%	37%	27%	20%	

Table 10: Identified project industries in SLR

Year	Agriculture	Construction	Cross industry	Software	Renewable Energy	Tot:
1991 – 1995		1	5	1		7
1996 – 2000		1	1			2
2001 – 2005		3				3
2006 – 2010		4				4
2011 – 2015		3	1	1		5
2016 – 2020		3	3			6
2021 – July 2024	1	13	16	5	1	36
Total:	1	28	26	7	1	63
Percentage:	2%	44%	41%	11%	2%	

From the 63 papers, we identified nine project knowledge areas: control, cost, decision-making, effort estimation, knowledge management, planning, risk, scheduling, and stakeholder management, see Table 11. Most papers did not study a specific project area, however, the most areas are project planning 19%, control 13%, and decision-making 11%. We suggest there is potential to increase research in underrepresented areas such as decision-making, knowledge management, and stakeholder management. More importantly, in a fast-paced PM business context, the abovementioned areas are significant in ensuring efficient project results.

Table 11: Identified knowledge areas optimised by AI in SLR

Year	CL	CT	DM	EE	KM	ND	PL	RM	SC	SM	Tot:
1991 – 1995			1			1	3		2		7
1996 – 2000							1		1		2
2001 – 2005			1		1		1				3
2006 – 2010	1	2							1		4
2011 – 2015	1			1			2			1	5
2016 – 2020	3		1				1	1			6
2021 – July 2024	3	1	4		2	15	4	5	1	1	36
Total:	8	3	7	1	3	16	12	6	5	2	63
Percentage:	13%	5%	11%	2%	5%	25%	19%	10%	8%	3%	

Knowledge areas abbreviations: Control (CL), Cost (CT), Decision-making (DM), Effort estimation (EE), Knowledge management (KM), Not defined (ND), Planning (PL), Risk management (RM), Scheduling (SC), Stakeholder management (SM)

4.5 Discussion

To bring clarity and deepen the understanding of how AI is applied in PM, we systematically analysed the literature based on 63 research papers. The result section answers our two first research questions: 1) *"What themes define project management and AI literature?"* 2*) "What trends can be identified in project management and AI literature?"* The third research question will be answered in the following discussion section: 3) *"What future research agenda can be identified from project management and AI literature?"*

We demonstrated how four main methodological themes conceptually discuss the opportunities and challenges of AI in projects, apply individual or hybrid AI models to optimise project knowledge areas, and conduct contemporary empirical findings of project practitioners' perceptions and use of AI. The number of papers using AI models for optimisation has increased since 2021, demonstrating the recent increase in using AI technology to improve project processes. There may be multiple reasons behind this increased interest, e.g. AI depends on progress in computer science, the increased accessibility to project data, and understanding of AI among project researchers (Cubric, 2020).

In a future agenda for the PM community we predict the use of AI in project DSSs will increase. The empirical papers in our review suggest that it is a matter of 'how', rather than 'if' AI will impact PM. We identify four main paths and propose the following research agenda: 1) Increase

the number of empirical publications studying project managers' perceptions and decision-making when using AI. 2) Continue optimising project knowledge areas through AI-based OR research and include optimisation of non-traditional project knowledge areas. 3) Further understanding of the use of project data. 4) Develop a closer collaboration between researchers and practitioners.

4.5.1 Increase Empirical Research on AI in PM

It is suggested that AI will become embedded in PM, requiring project managers' to require AI knowledge (Niederman, 2021). Our review shows the extent to which available AI DSSs reduce project managers' subjective decision-making (Phillips-Wren et al., 2019). To increase the use of AI DSSs, we suggest focusing on empirical research to understand project managers' and practitioners' use of AI. Further, we suggest that decision-making, knowledge management, and stakeholder management are areas with the potential to be studied further, and we suggest applying empirical research to these areas. None of the empirical papers study managers' decision-making and behaviour when using AI-based DSS for projects. This is a significant research gap. It would be beneficial to study through the concepts of 'heuristics', where the decision-maker uses rules of thumb to simplify their decision processes (Loock and Hinnen, 2015). The field of heuristics is related to bounded rationality and can be traced back to early work of decision-making (Simon, 1947, Simon, 1972, Simon, 1977b, Simon, 1977a), which is still a current topic through contemporary publications (Flyvbjerg, 2021, Loock and Hinnen, 2015, McCray et al., 2002, Natarajan, 2022, Shore, 2008, Stingl and Geraldi, 2021). The specific area of understanding users' behaviour of OR tools and AI-based DSSs is found within Behavioural OR. We suggest further studying AI's impact on decision-making processes and studying the research gap between project decision-making and AI.

Advanced AI models may apply machine learning AI techniques to analyse large datasets effectively. However, these advanced models suffer from a trade-off of interpretability and explainability. More advanced AI models often bring challenges to interpret and explain the outputs, also known as the 'AI-black box' (Arrieta et al., 2020, Gunning and Aha, 2019, Langer et al., 2021, Mahbooba et al., 2021, Rai, 2020). This highlights the challenge for managers using machine learning AI models to justify their reasoning for a decision. We suggest further studying project managers' behaviour and decision-making processes when using advanced AI DSSs. Additionally, project managers may ask themselves: 'How can I justify and explain the AI results to the stakeholders?' This leads to further interest in understanding project managers' trust in AI (Wachnik, 2022), and the behavioural impact, including potential behavioural biases when using AI DSSs.

4.5.2 Apply AI for Non-traditional Optimised Areas

We identified the literature on AI in PM to include nine project knowledge areas. Our review suggests that qualitative project areas, such as decision-making, knowledge management, and stakeholder management, are challenging for AI to analyse due to the lack of access to data (Fridgeirsson et al., 2021, Kumar et al., 2021). Further, we suggest continuing optimising project knowledge areas through AI-based OR research and expanding AI optimisation to include non-traditional project knowledge areas, such as communication within stakeholder management. This is aligned with the literature suggesting managing teams and knowledge management are difficult areas to apply AI optimisation (Holzmann et al., 2022). Although soft skills are challenging for AI to analyse, we identify that the use of AI can be beneficial for stakeholder management through improved forecasts of stakeholder disputes in construction projects (Li et al., 2021, Zheng et al., 2021). The complexity of construction disputes is highlighted by Ojiako et al. (2021) and it is an area where AI can have many user areas outside the construction industry.

Applying AI for stakeholder management does not replace managers' role in communicating with stakeholders, it rather augments communication during conflict resolution. We suggest a research gap exists in applying AI for root cause analysis during project delays and identifying patterns in stakeholders' behaviour and communication. This approach enables project managers to avoid stakeholder conflicts, which may result in project delays and cost overruns. Our review demonstrates an interest in using AI beyond established OR optimised knowledge areas. Established quantifiable knowledge areas, such as project planning and scheduling, can be studied through the well-known research field 'resource constrained project scheduling problem' (RCPSP) (Hartmann and Briskorn, 2022). The areas of project scheduling and planning have seen a significant influence from OR through mathematical modelling, schedule optimisation, and provide tools to evaluate project performance (Tavares, 2002, Williams, 2003).

4.5.3 Further Understanding of Project Data

Our review suggests that researchers further conduct empirical research and study non-traditional optimised knowledge areas. We recommend researchers deepen their understanding of project data to enable further use of AI DSSs in projects. It is suggested to follow Vanhoucke et al. (2016), who suggest that project data should include 'static data' (data prior to project execution), and 'dynamic data' (data generated during project execution). For this purpose, using high-quality project data is significant for this purpose consisting of 'real-life' project data (Batselier and Vanhoucke, 2015). Additionally, practitioners need to

understand project data to a degree where they can detect and manage faulty data (Niederman, 2021).

Our review demonstrates a significant emphasis on researching construction projects. We conclude that construction project data currently exists for research purposes. During the search process, a review of the search string was carried out to mitigate any bias. However, the search string was found to be neutral, and no changes were made to it. The over-representation of papers in this industry tells us that construction projects successfully generate and share data. We urge other project industries to generate, store, and share data similarly. This will enable academics to study and optimise project areas outside the construction industry.

4.5.4 Collaboration Between Researchers and Practitioners

For the final research path, we propose a closer collaboration between the research community and practitioners that will enable an understanding of practitioners' perceptions of AI technology and provide access to more project data. Researchers interested in our suggested agenda are encouraged to apply empirical research on how AI DSSs impact project managers. We argue that projects will continue to be influenced by AI in a short-term perspective through optimisation within project planning and scheduling areas. From a long-term perspective, we propose that non-traditional optimised areas based on qualitative elements such as stakeholder and knowledge management will see an impact from AI. There is potential to study these areas through generative AI (Aljaž, 2024). We suggest further collaboration between project researchers and practitioners as a critical step in this development. Additionally, project researchers need to find inspiration from other management research fields such as IT, healthcare, and finance.

4.6 Conclusion

Our research paper reviewed the literature on AI in PM to synthesise previous work in this field and to provide a future agenda. Based on the search terms 'project management' and 'artificial intelligence' with further inclusive criteria, we analysed 63 published between 1991 and July 2024. Our review is limited to a systematic approach and has provided transparency for the research method to be replicable.

We identified how AI is studied through four methodological themes: through conceptual discussions of the opportunities and challenges of AI, optimising project knowledge areas through individual or hybrid AI models, and empirical papers studying project practitioners' perceptions of AI. Additionally, we found nine knowledge areas studied through AI: project

control, cost, decision-making, effort estimation, knowledge management, planning, risk, scheduling, and stakeholder management.

The review culminated in a future agenda for the PM community: 1) We suggest focusing on empirical research to study project managers' decision-making and behaviour when using AI-based DSS for PM. Our review finds the area of decision-making to be a commonly studied knowledge area. However, advanced AI models have the trade-off of more advanced analysis, nonetheless a lower ability for explainability through the 'AI-black box'. This leads to complex decision-making when managers need to justify their decisions. We suggest further understanding the decision-making process of managers using AI DSSs is crucial. 2) The review suggests that AI optimises non-traditional quantified project knowledge areas. Our review demonstrates the potential to study qualitative areas such as stakeholder and knowledge management. 3) We suggest that researchers and practitioners further understand project data. Improving the understanding of project data will enable the further application of AI DSS in projects. This includes industries outside the over-represented project construction industry. 4) Collaboration between researchers and practitioners is critical for this research agenda.

Our review is a step towards a more structured PM and AI literature. We propose referring to the findings of our SLR as a reference point for the project community. However, we recognise that the field of AI in PM is in its initial state. Rather than predicting how this field will develop, we propose an agenda to inspire project researchers to study this emerging field further.

Chapter 5 Second Research Paper

Title: The Impact of Artificial Intelligence on Project Managers' Behaviour: An Exploratory Study

Abstract

While "Artificial Intelligence" (AI) has been applied to project optimisation tasks, there is currently limited research on the impact on project managers' behaviour when using AI to support decision-making related to the control of project execution. This paper is an evaluation of the application of AI in project management through the lens of "Behavioural Operational Research" (BOR). The research is based on 22 interviews with project managers to understand their behaviour when using AI models. We found that project managers present an "Escalation of Commitment" (EoC) behaviour when using AI as a project control tool. The research contributes to the literature of BOR through the behavioural construct we call "the wait effect". The findings are presented through Causal Loop Diagram and the paper suggests that managers' EoC behaviour is driven by "the wait effect" and the willingness to take corrective action is dependent on the trust in AI model.

Keywords: Behavioural OR; Project Management; Artificial Intelligence, Control; Causal Loop Diagram

5.1 Introduction

Project control is a significant activity performed by project managers and involves measuring project progress while ensuring mitigation actions are taken when project tolerances overrun (Acebes et al., 2014, Martens and Vanhoucke, 2017, Olawale and Sun, 2015, Rozenes et al., 2006). Contemporary project control "Decision Support Systems" (DSSs) based on "Artificial Intelligence" (AI) have the potential to enhance the analytical ability of traditional project tools and act as early warning systems to identify project disruption more efficiently (Hazır, 2015, Pellerin and Perrier, 2019). Previous research suggest project managers have cognitive barriers hindering them from responding to early warning signs based on over-optimism, normalisation of deviance, and lack of an outside view (Haji-Kazemi et al., 2015). Such cognitive barriers lead project managers to continue investing in failing projects, which is known as the phenomenon of "Escalation of Commitment" (EoC) (Drummond, 2014, Sleesman et al., 2018, Zhang et al., 2003, Staw, 1997, Wang et al., 2020b). The behavioural construct of EoC is a well-established research field and is recognised within "Behavioural Operational Research" (BOR) (Ford and

Sterman, 2003, Pala et al., 2015, Son and Rojas, 2011, Van Oorschot et al., 2013, Wang et al., 2017, Wang et al., 2020b). However, there is a gap in the literature studying whether EoC continues when project managers apply project control tools based on AI technology.

To assist project managers during the project control phase, there are different quantitative project management tools and techniques (Hazır, 2015), and AI has the potential to improve the generation of early warning signals leading to more effective corrective action (Pellerin and Perrier, 2019). In recent decades, studies find AI technology gaining attention from organisations to drive business and improve efficiency in management processes (Cubric, 2020, Vidgen et al., 2020). Further on, AI is used successfully in business areas such as finance (Fethi and Pasiouras, 2010), banking (Doumpos et al., 2023), business forecasting (Lee and Shin, 2020), and management recruitment (Black and van Esch, 2020). A recent report suggests that industry is racing ahead of academia in terms of AI knowledge due to the rapid AI industry development (Maslej et al., 2023). Additionally, approximately 80% of large business organisations plan to implement some form of AI technology as part of their core business (Ghosh et al., 2019). This indicates the significant interest in AI from business decision-makers and it becomes crucial to understand the behavioural impact of decision-makers from a project management and OR perspective.

The field of project management utilises AI technology to optimise areas such as cost simulations in high-risk projects (Badiru and Sieger, 1998), predicting project escalation (Zhang et al., 2003), estimating project duration (Wauters and Vanhoucke, 2017), cost estimation (Cheng et al., 2015), resource-constrained project scheduling (Pellerin et al., 2020, Servranckx and Vanhoucke, 2019), and prediction of stakeholder disputes on construction projects (Chaphalkar et al., 2015). Some researchers go beyond optimising tools and suggest that factors such as feasibility, ease-of-use and effectiveness play an important role when applying AI technology (Hofmann et al., 2020). Another example is when researchers study the use of chatbots and AI agents in project teams (Dennis et al., 2023, Nyqvist et al., 2024, Onal and Kulavuz-Onal, 2024, Skuridin and Wynn, 2024, Xiang et al., 2022). However, research and practice demonstrate challenges when it comes to interpreting and explaining the output of advanced AI models, also known as “black-box AI” (Ali et al., 2023, De Bock et al., 2024, Dwivedi et al., 2023, Gkinko and Elbanna, 2023). Explainable AI (XAI) involves the ability of the user to interpret the model which is essential for the user to understand and trust the AI (Gunning and Aha, 2019). To summarise, using AI is challenging for project managers when they must justify their actions during the project control process. Therefore, applying AI tools in a project context introduces new complexities for decision-making. Hence, it becomes important to understand project managers’ behaviour when relying on AI to support their decisions (Hsu et al., 2021).

Complex project dynamics can arise when managers face delay and disruption to the project plan (Williams et al., 2003). The ripple effects caused by project disruption can have a negative impact on project performance and lead to unexpected changes in the project schedule (Lyneis and Ford, 2007). Research demonstrates how these dynamics typically go beyond project managers' cognitive ability to foresee the long-term effects of their decision-making (Ford and Lyneis, 2020, Sterman, 2000). Additionally, the consequences of applying corrective actions tend to go beyond project managers' ability to predict (Wang et al., 2017). Thus, it is important to investigate whether AI may help or hinder project managers' ability to control projects and its impact on their behaviour, especially through their biases to take corrective action. Managers' biases towards corrective actions are studied in BOR (Hämäläinen et al., 2013, Keller and Katsikopoulos, 2016, Kunc, 2016, White et al., 2020, Wang et al., 2020b) and our research follows this rich tradition through a set of interviews with 22 project managers using AI to manage their projects. Then, we synthesise the findings using a Causal Loop Diagram and suggest a behavioural theory of project managers using AI-based control tools (Yearworth and White, 2013).

The paper aims to answer the following research question: *How do behavioural theories or constructs affect project managers during the project control process when using Artificial Intelligence technology as early warning sign tools?* The research question is answered through the following three objectives: 1) Capture project managers' mental models when using AI for project control. 2) Identify variables that influence project managers' behaviour when using AI during project control. 3) Identify behavioural heuristics that influence project managers' behaviour when using AI for project control.

The paper is structured in the following way: the literature review includes research on project control tools and AI technology, as well as project managers' behaviour during project control through BOR. This is followed by our research method, results, discussion, and conclusion where we elaborate on our main contribution "the wait effect" with the underlying factors of AI explainability, project uniqueness, and trust in the AI model. We suggest these factors influence project managers' willingness to take corrective action when using AI.

5.2 Literature Review

5.2.1 Project Control and Monitoring

Project control includes the activity of comparing the baselined project plan with the actual project performance (Acebes et al., 2015, Vanhoucke, 2012a), and the literature can be divided in three phases: 1) improving control techniques for project cost and time, 2) studying the

causes and consequences of project delay and cost overruns, and 3) practical case studies on this topic (Olawale and Sun, 2015). Further on, decision-making during project control can be classified into the following four areas: evaluating project performance, forecasting project duration, the optimal timing of control points, and the generation of early warning signals to trigger corrective actions (Pellerin and Perrier, 2019).

Based on the mentioned project control phases, the literature show that research in control is predominantly combined with project planning and scheduling (Coelho and Vanhoucke, 2020, Demeulemeester and Herroelen, 2006, Hartmann and Briskorn, 2010, Hazır, 2015, Herroelen and Leus, 2005, Pellerin and Perrier, 2019, Pellerin et al., 2020, Vega-Velázquez et al., 2018). Control tools originate from established planning and scheduling techniques such as "Critical Path Methods" (CPM) and "Program Evaluation and Review Technique" (PERT) (Vanhoucke, 2012b). CPM is based on a single-point estimate, whereas PERT use a three-point estimate. The techniques are suggested to be the earliest computer-based DSS techniques in project management that became widely adopted by the project community (Trietsch and Baker, 2012). There are limitations to these techniques and they are not efficient for all control scenarios, e.g. they are deterministic and CPM traditionally assumes resources are unlimited where a new project activity can begin regardless of the circumstances as long as the previous task is completed (Wu et al., 2014).

Dynamic scheduling is a suggested concept by Vanhoucke (2012a) when updating project baselines, and adjusting the project schedule according to new circumstances is best practice when an adaptable project methodology is used (Pellerin and Perrier, 2019). Dynamic scheduling involves updating the baseline schedule in relation to a Monte Carlo schedule risk analysis and earned value metrics. As a critical element of project scheduling, "resource constrained project scheduling problem" (RCPSP) has seen great attention from OR researchers with a recent focus on heuristic methods with less deterministic scheduling solutions (Hartmann and Briskorn, 2022, Vanhoucke and Coelho, 2024, Servranckx et al., 2024). As an example, Servranckx and Vanhoucke (2019) use the metaheuristic algorithm of "tabu search" to optimise RCPSP. After reviewing the literature, Pellerin et al. (2020) find that heuristic methods for RCPSP are combined with deterministic solutions to form hybrid metaheuristics. Whereas Sánchez et al. (2023) recently reviewed the literature on RCPSP in a multi-project environment, and Zhang et al. (2024) suggest a three-dimensional RCPSP model optimising the space available on construction sites to execute the scheduled activities.

Although research in project control relates to planning and scheduling, this paper makes a distinction between these areas based on the work by Olawale and Sun (2013). According to the mentioned authors, project control is a complex and iterative activity which typically includes

three phases; 1) setting performance standards, 2) comparing actual performance with project baseline standards, and 3) taking necessary corrective actions. For this research paper, we make a distinction between these areas by focusing on the second and third control phases mentioned by Olawale and Sun (2013). Additionally, we include "rework discovery" as a significant activity while comparing actual performance and baseline standards (Ford and Lyneis, 2020).

5.2.2 Project Control Tools

Project managers use DSSs and quantitative project tools to assist their decision-making. Effective DSSs for project control include two significant concepts; 1) an analytical model with algorithmic solutions for simulation or optimisation purposes, and 2) the ability to generate graphical interfaces for managers to visualise alternatives before making decisions (Hazır, 2015, Jüngen and Kowalczyk, 1995). The field of OR has a significant role in developing analytical project tools through network modelling, project scheduling optimisation, as well as methods for monitoring and performing project evaluations (Tavares, 2002).

Typically, control tools use a single-dimensional measurement to address a project objective, e.g. the number of rework, cost, or schedule. Additionally, there are multidimensional tools that consider more than one project parameter (Lipke et al., 2009, Rozenes et al., 2006). A challenge with measuring single parameters becomes evident when the project schedule suggests the project is on time, while the project is running over budget. Only measuring the project schedule does not provide the actual status of the project (Bryde et al., 2018). On the other hand, a multidimensional control tool brings further dynamics to the control process. "Earned Value Management" (EVM) is an example of a multidimensional project tool including both time and cost (Acebes et al., 2014). An additional tool is Optimal Control Theory, which is based on mathematical optimisation to determine the most effective control policies (Acebes et al., 2014, Kapur et al., 2013). Optimal Control Theory optimises resource allocation to minimise costs in software projects (Kapur et al., 2013). Also, Monte Carlo is a significant tool for risk management to be used during project control (Kwak and Ingall, 2007, Vanhoucke, 2013). The method uses iterative simulations to replicate the project outcome (Kwak and Ingall, 2007). Limitations of Monte Carlo include that it is most accurate towards the end of the project life cycle, thus it is not optimal to use during the entire project control process (Acebes et al., 2014), as well as it is a time-consuming method involving multiple simulations (Kwak and Ingall, 2007).

5.2.2.1 Earned Value Management

EVM is a widely studied project control technique which includes more than one dimension to measure project progress (Acebes et al., 2014, Hazır, 2015, Pellerin and Perrier, 2019, Rozenes

et al., 2006, Song et al., 2020). The technique is based on a top-down approach performed at the aggregated project level (Song et al., 2022). The purpose of EVM is to measure project progress according to the plan through variables such as cost and schedule variance (Lipke et al., 2009). It is then used to estimate future outcome of the project (Acebes et al., 2014). The "earned value" is the actual project work completed at a single point in time (Plaza and Turetken, 2009).

There are several challenges when using EVM, including it is developed for a deterministic project environment and excludes project uncertainty as a parameter. This leads to EVM is not an optimal tool in projects with high levels of uncertainty (Acebes et al., 2014). An additional challenge is that EVM only measures the parameters of time and cost, whereas other success criteria such as design and quality are not typically integrated with this tool (Rozenes et al., 2006). According to Plaza and Turetken (2009), further limitations include the assumption that the project team performance is constant throughout the project life cycle rather than the usual tendency of project teams' efficiency to increase as members become more experienced as the project progresses. The same authors suggest that support tools for EVM should include the learning process within project teams. Additionally, to reduce the deterministic aspect of EVM, a buffer method is proposed to increase the tolerances for costs and schedule (Martens and Vanhoucke, 2017). To mitigate the limitation of EVM during project uncertainty, Acebes et al. (2014) introduce risk analysis to EVM through the Monte Carlo method. This combination integrates the EVM tolerances for time and costs with the Monte Carlo risk analysis to allow project managers to consider corrective actions during high project uncertainty.

5.2.2.2 AI based Project Control Tools

Project management has seen critical development in the use of AI to support project control. For example, early research by Jüngen and Kowalczyk (1995) propose developing interactive project support systems based on AI, and the influence of AI tools in OR has been discussed for a significant time (Hendry, 1987, Pomerol, 1997, Rosenthal-Sabroux and Zaraté, 1997). Several researchers further develop hybrid AI models by combining multiple AI techniques to optimise the financial side of project control and project cash flow (Cheng et al., 2020, Cheng et al., 2015, Cheng and Roy, 2011, Cheng et al., 2009c). Researchers demonstrate that neural networks are effective for optimising project control activities such as scheduling, cost and quality (Garcia et al., 2017) and for predicting software project escalation (Zhang et al., 2003). Additionally, when AI techniques are combined with the traditional EVM technique, the EVM method shows an improved cost and schedule accuracy (Wauters and Vanhoucke, 2016, Willems and Vanhoucke, 2015). Additional studies of EVM and AI have seen similar results (Hajiali et al., 2020, Wauters and Vanhoucke, 2017). See Table 12 for a summary of contemporary project control and AI literature.

Table 12: Literature of optimising project control through AI

Authors	Article Description
Al-subhi et al. (2021)	The paper studies the use of AI techniques in project management to optimise project evaluation.
Amândio et al. (2021)	The paper studies how AI algorithms are used to optimise project management road construction for optimal allocation of heavy equipment.
Choi et al. (2021)	The paper discusses optimising decision support systems through several AI models to improve project risk management in engineering, procurement and construction projects.
Darko et al. (2023)	Applies an AI model to predict project cost and duration based on green sustainability factors.
Greeshma and Edayadiyil (2022)	The authors suggest applying an AI image processing method to monitor construction progress.
Liu and Hao (2021)	The paper studies the optimisation of project scheduling through AI techniques.
Lung and Wang (2023)	The research focuses on the optimisation of image recognition through AI neural networks.
Uddin et al. (2022)	The authors study to predict cost-overrun in construction projects through several AI models.
Varouqa (2021)	The paper studies optimisation through AI of project prediction of cost and duration in construction projects.
Zhou and Zou (2021)	The paper studies how an AI model can assist in complex project decision-making.

5.2.2.3 Project Data Challenge

One of the challenges when applying AI methods is managing data (Cubric, 2020, Lee and Shin, 2020, Vanhoucke et al., 2016, Wang et al., 2016). AI models depend on the data, and like any OR tool, the model's output reflects the input data (Kockum and Dacre, 2021). However, different projects vary in the ability to generate project data, e.g. "research and development" (R&D) projects generally have a low amount of relevant historical data, compared to construction projects with more standardised processes to generate data. The variety in available data across industries suggests it becomes challenging to implement AI extensively in project management (Martínez-Rojas et al., 2016). Additionally, project managers' access to data depends on the frequency of reporting activities that occur at specific time intervals or are dependent on certain work quota (Raz and Erel, 2000).

According to Vanhoucke et al. (2016), project data consists of "static" or "dynamic data". Static project data is employed during the planning stage, where baseline project requirements make up the project scheduling and planning. Dynamic data refers to the generated data during the project and is used for measuring and tracking the progress, consisting of empirical and artificial data (Anouchka et al, 2016). Challenges of using empirical project data include the inconsistency of relying on project managers' intuition to decide what data is relevant to measure, challenges to re-use data between projects, and the variation of quality in

unstructured data (Vanhoucke et al., 2016). Artificial data originates from project simulation methods, such as Monte Carlo. The disadvantage of this type of data includes the challenge of validating the assumptions behind the simulation (Acebes et al., 2015, Qazi and Simsekler, 2021).

5.3 Trust in AI Technology

Individuals' trust in AI technology is a significant topic when discussing A and decision-making. In Table 13 we present literature on this topic. The publications range from analytical to generative AI, and research is applied to multiple industries. Our paper focuses on project managers' behaviour when using AI as an analytical tool for project control and we discuss "AI trust" as a critical factor.

Having an incorrect level of AI trust leads to complications (Makarius et al., 2020). Low trust in high-performing AI leads to inefficiency through lost opportunity and disuse, whereas high trust in low-performing AI results in overusing and optimism bias towards a specific AI tool (Hoff and Bashir, 2015). Therefore decision-makers must have appropriate trust and understanding of the AI model. Glikson and Woolley (2020) suggest the factors of "transparency", "tangibility", "immediacy behaviour", and "reliability" in the AI system are significant for building individuals' trust in AI. Research suggests users' trust in AI increases when the AI model includes human-like behaviour (Shin et al., 2022), also known as anthropomorphism, which is a well-established research area (Cabiddu et al., 2022).

Table 13: Literature on management decision-making and AI

Publications	Research contribution	Applied theory
Cao et al. (2021)	The authors suggest a model, "AI Acceptance-Avoidance Model" (IAAAM), to predict managers' attitudes and behavioural intentions of using AI for organisational decision-making.	Combination of Unified Theory of Acceptance and Use of Technology (UTAUT) and Technology Threat Avoidance Theory (TTAT)
Duan et al. (2019)	The paper suggests researching management decision-making based on "theoretical development", "AI technology-human interaction", and "AI implementation".	Literature review of AI and decision-making in information systems research
Felicetti et al. (2024)	The authors identify the effective application of generative AI in project management based on the factors "Innovation Attitude", "Peer Influence", and "Task-Technology Fit".	Adaptive Structuration Theory
Hermann and Puntoni (2024)	The research reviews the literature on users' behaviour when applying generative AI. The authors propose the concepts of "Convergent Thinking Gen AI" for domain-specific tasks, and "Divergent Thinking GenAI" for general domain tasks.	Literature review of generative AI
Liu et al. (2024)	The authors study hospitality employees' behaviour when using AI for customer service, decision optimisation, marketing, and operational efficiency.	Conservation for Resources Theory

Publications	Research contribution	Applied theory
	They suggest AI improves self-efficacy while also creating workplace anxiety.	Approach Avoidance Systems Theory

5.3.1 Explainable AI

Users of advanced AI models typically experience difficulties interpreting the model's outputs (Hoffman et al., 2018). This is known as "the AI-black box" and is a challenge for decision-makers to justify their confidence in an AI model (Barredo Arrieta et al., 2020). To address this challenge, scholars have created the concept of AI explainability (XAI) (Gunning and Aha, 2019, Hoffman et al., 2018, Miller, 2019, Shin and Park, 2019). De Bock et al. (2024) suggest XAI in OR be based on three factors: "performance analytics", "attributable analytics", and "responsible analytics". Performance analytics is a minimum requirement for XAI in OR and involves the core functions of OR through optimisation and problem-solving. This refers typically to individuals in data science, operations, and IT. Further on, according to De Bock et al. (2024), attributable analytics is a must-have requirement relevant to organisational decision-makers to improve advanced AI models through the attributes of understandability, justifiability, and actionability. Several attempts are made to improve XAI, e.g. using a decision-tree algorithm enhances users' AI trust as this technique allows the user to interpret the model and understand the AI output (Mahbooba et al., 2021). Although XAI models have increased interpretability, their disadvantage is a lower prediction and learning capability (Lee and Shin, 2020). This trade-off causes higher AI prediction accuracy while having a lower level of explainability (Rai, 2020). XAI models should enable the user to understand whether, when, and why specific AI outputs are provided (Hoffman et al., 2018). However, it is not possible for AI models to include all attributes, leading decision-makers to choose AI models dependent on their specific explainability requirements (Barredo Arrieta et al., 2020). The last factor mentioned by De Bock et al. (2024), responsible analytics refers to legal compliance, frugality, and ethical responsibility. It is suggested to be a should-have requirement and targets a wider set of organisational stakeholders. To manage multiple stakeholders' preferences, Langer et al. (2021) suggest using AI models with specific explainability attributes. To maintain consistency in XAI, organisations are suggested to form review panels to assess the transparency of AI models (Benbya et al., 2020). This research field is in a novel stage and there are different interpretations of explainability in AI models, leading to a wide range of attributes discussed in the literature, e.g. fairness, unbiasedness, causality, trustworthiness, causality, and transferability (Barredo Arrieta et al., 2020, Doshi-Velez and Kim, 2018, Miller, 2019).

5.4 Behavioural OR and Project Management

Researching the behaviour of decision-makers using OR tools has seen significant attention during the last three decades (Franco et al., 2021, Kunc and Katsikopoulos, 2022, White, 2016, Ackermann, 2024), and it is evident that project managers experience complex decision-making (Killen et al., 2020). Hämäläinen et al. (2013) state that the OR field long ignored the individual decision-maker's perspective by only studying how to improve optimisation algorithms. BOR researchers aim to explain managers' decision-making heuristics and study behaviour through descriptive decision theory by demonstrating the actual use of OR tools (Kunc et al., 2016). Expanding on BOR is critical for the OR field as the behaviour of OR users is crucial to understand when improving OR tools (Keller and Katsikopoulos, 2016).

BOR is suggested to follow the perspectives of "behaviour in models", "behaviour beyond models", and "behaviour with models" (Kunc and Katsikopoulos, 2022, Kunc et al., 2016, White et al., 2020). Behaviour in models represents individuals modelled as part of the OR model, whereas behaviour beyond models studies the impact beyond the OR model, e.g. policy changes due to OR research. Our research adopts behaviour with models, meaning we study individuals' behaviour when using OR models, i.e. project managers using OR models in the context of AI control tools. AI has shown promising results in improving decision-making hence it becomes significant to study this field in the context of OR (Kunc and Katsikopoulos, 2022).

Project managers' decision-making is influenced by biases and cognitive limitations (Stingl and Geraldi, 2017a). According to Wang et al. (2020b) project managers' behavioural issues consist of three main theme: 1) Escalation of Commitment, 2) biased forecasts and planning, and 3) reluctance to blow the whistle. Table 14 presents these concepts categorised by specific project phases and the underlying behavioural constructs. The following sections explain these behavioural constructs in more detail.

Table 14: Project Managers' Bias Behavioural Constructs adapted by Wang et al. (2020b)

Project Phase	Monitoring and Control	Initiating and Planning	Reporting
Behavioural Issue	Escalation of commitment (EoC)	Biased forecasts and planning	Reluctance to blow the whistle
Behavioural Constructs	Optimism bias Sunk cost effect (prospect theory) Completion effect Goal incongruence	Anchoring Optimism bias Strategic misrepresentation	Mum effect Deaf effect

5.4.1 Escalation of Commitment

During project control, managers experience project escalation where the behaviour of EoC is a well-established bias. This concept explains decision-makers' continuous investment in projects while ignoring signs of escalation (Staw, 1997). Studying project escalation and related biases of project managers are well-established in the literature (Ford and Sterman, 2003, Pala et al., 2015, Son and Rojas, 2011, Wang et al., 2017). Keil et al. (2000) suggest that the number of projects suffering from EoC is unknown as it is not in managers' interests to report project escalation. During project disruption, the project manager can choose de-escalating actions by slipping the deadline or adding staff resources by increasing work hours (Ford and Lyneis, 2020, Lyneis and Ford, 2007). Additional de-escalation includes terminating the project pre-maturely (Keil and Robey, 1999). However, defining de-escalation is not a simple task. Feldman and Wong (2018) discuss the action of continuing project escalation as "doing nothing". Further, they suggest managers' intentions of escalation to be considered an "action" or "inaction". The same authors propose de-escalation to be known as "action" and EoC behaviour to be referred to as "inaction". However, the literature is not aligned with this definition. Theories explaining EoC include self-justification theory, agency theory, approach-avoidance theory, and prospect theory (Keil et al., 2000). According to Wang et al. (2020b), EoC occurs in the project control phase and is represented by the constructs of optimism bias, sunk cost effect (prospect theory), completion effect, and goal incongruence, see Table 14. The mentioned constructs complement each other and provide an overall explanation of this phenomenon.

Optimism bias is an umbrella term for various cognitive biases and is active within project control, project initiation and project planning (Meyer, 2014, Son and Rojas, 2011, Stingl and Geraldi, 2017a). It explains a subset of various cognitive biases where the decision-maker makes an overestimation of positive outcomes and an underestimation of negative outcomes (Stingl and Geraldi, 2017a). Other researchers explain this behaviour through overconfidence and confirmation bias (Loch, 2017, Winch, 2013).

The sunk cost effect, also known as prospect theory, suggests that the decision-maker is prone to risk-seeking behaviour (Kahneman and Tversky, 1979, Wang et al., 2017, Wang et al., 2020b). The decision-maker continues to spend resources on a failing project in the hope of saving the project since resources already invested in the project would otherwise be lost (Keil et al., 2000).

The *completion effect* relates to the approach-avoidance theory, where escalation is encouraged through proximity to the project completion (Keil et al., 2000). Mann (1996) explains the completion effect as a "pull" for project completion, whereas the sunk cost effect represents a "push" for the project continuation. Furthermore, the "90% syndrome" explains

the completion effect through managers' perception of the project as "almost completed", which will make them continue the escalation (Buxton and Rivers, 2014, Ford and Sterman, 2003).

G*oal incongruence* is found in agency theory, where project objectives are misaligned and managers are driven by personal goals (Keil et al., 2000). This behaviour is driven by self-interest and does not prioritise the interest of achieving the project objectives (Sleesman et al., 2018). Agency theory is based on the roles of an "agent" and a "principal", where the agent is acting as a decision-maker on behalf of the principal and goal misalignment occurs through information asymmetry between these roles (Jensen and Meckling, 1976, Keil et al., 2000).

5.4.2 Biased Forecasts and Planning

The biased behaviours of forecasting and planning include the constructs of optimism bias, anchoring and strategic misrepresentation (Lovallo and Kahneman, 2003). These biases take place during the project initiation and planning phase (Wang et al., 2020b). However, clear boundaries between the biases and the project phases do not exist since optimism bias also appears during project control.

Anchoring occurs when decision-makers have an "anchor" to a piece of information through an emotional attachment. This is demonstrated when the individual favours the emotional attachment while other options are deprioritised (Son and Rojas, 2011). The anchor works as an initial reference point, and the decision-maker ignores new information (Lovallo and Kahneman, 2003). *Strategic misrepresentation* is related to the planning phase, where Flyvbjerg et al. (2002) suggest that this construct is based on planning fallacy, where the decision-maker intentionally provides an incorrect project plan.

5.4.3 Reluctance to Blow the Whistle

Behaviour during project reporting is sometimes referred to as reluctance to blow the whistle, and involves the unwillingness to accept unsatisfactory outcomes (Wang et al., 2020b). *The mum effect* explains when the messenger of negative news is reluctant to inform the receiver (Keil and Robey, 2001, Park et al., 2008). Whereas *the deaf effect* refers to when the receiver does not acknowledge negative news from the messenger (Cuellar et al., 2006, Keil and Robey, 2001). Researchers identify the mum effect and deaf effect to be significant in software projects (Cuellar et al., 2006, Keil and Robey, 2001, Park et al., 2008).

5.5 Research Methodology

We conducted semi-structured interviews with project managers using AI tools during project control (Glaser and Strauss, 2017). The interviews were held with project managers from different industries to represent a cross-industry project environment. We adopted an exploratory approach, which is suitable for the technique of Grounded Theory (Glaser and Strauss, 1967). This allowed the research to explore themes that emerged during the data collection. Then, themes were integrated into a theory of behavioural dynamics generated by project managers using AI to manage projects through a "Causal Loop Diagram" (CLD). This modelling technique is developed through qualitative interactions, such as interviews, with decision-makers to construct feedback loops representing their behaviour (Kunc, 2016, Kunc, 2017a). CLD is used to generate research insights in the field of Operational Research (OR) (Yearworth and White, 2013), as well as for understanding managers' strategic thinking (Torres et al., 2017). It is one of the techniques in System Dynamics modelling, and according to several researchers, combining Grounded Theory and System Dynamics modelling is a suitable approach (Kopainsky and Luna-Reyes, 2008, Luna-Reyes and Andersen, 2003). Additionally, using qualitative data in the form of interviews to develop CLDs is an established method (Yearworth and White, 2013). CLD is an established method to display disruption and delays in projects (Williams et al., 2003), and System Dynamics is commonly used to model project managers' behaviour (Abdel-Hamid, 2011, Cooper, 1993b, Ford and Lyneis, 2020, Ford et al., 2007, Ford and Sterman, 2003, Lyneis and Ford, 2007, Son and Rojas, 2011, Wang et al., 2017). It is specifically applied to demonstrate project managers' behaviour within BOR (Hämäläinen et al., 2013, Wang et al., 2020b).

The modelling approach is considered "soft systems modelling" since it involves understanding individuals' mental models of a phenomenon (Checkland, 2000, Morecroft, 2004), and capturing their behaviours (Kunc, 2016). The development of the qualitative CLD model follows the steps proposed by Kunc (2017a): 1) identifying the variables, 2) understanding the direction of causality, 3) assigning polarities of positive or negative relationships on the causalities, and 4) connecting variables to form feedback processes and determining the feedback loops as reinforcing or balancing.

5.5.1 Data Analysis

Prior to the interviews, the research applied for ethical approval at the University of Southampton. Interview participants were included based on their experience using AI as an analytical tool during the project control phase. The 22 individual research participants had experience interpreting the project progress directly from an AI DSS or interpreting the results

from a team member with the technical knowledge to analyse the AI output. The data was collected through digital qualitative interviews through Microsoft Teams during the period of January 2020 to May 2022. Having the results analysed by a team member was necessary when the project manager's AI knowledge was insufficient. The industry background of the participants is spread across the automotive, aviation, construction and IT industry. The behaviours discovered in the interviews apply to project managers' general behaviour, and the results provide an overall perspective of AI within cross-industry project management. We use the framework of Huang and Rust (2018) to categorise the type of AI models used by the interview participants.

We adopted the strategy and coding process of Grounded Theory, where interview data is analysed iteratively while studying the literature (Glaser and Strauss, 2017). The coding process of categorising and labelling data helped identify themes and explore complex dynamic interaction. The interview data was analysed through three steps of coding, open, axial and selective coding. Open coding in Grounded Theory examines the data to identify concepts and categories in the interview data (Glaser and Strauss, 1967). During the axial coding, relationships based on the open coding are identified. Lastly, the selective coding identifies core categories and themes. This step explains the connections of the themes and demonstrates the categories' relationships (Strauss and Corbin, 1990). Hence, the focus in this step constitutes developing a theoretical model that explores the connection between categories in line with our research question. It involved refining the theory as new data and insights emerged from the interview data. In practice, we identified variables from the interview data during the open coding, and then explained the variables' relationships during axial and selective coding. We repeated the process until data saturation, resulting in a CLD model. This modelling involves a behavioural theory that represents the cause-and-effect relationships between managers' use of AI and their decisions related to the control of projects as feedback loops (Luna-Reyes and Andersen, 2003). The coding process of the interview data underpinning the CLD is presented in Table 15.

Table 15: Coding process for the wait effect causal loop diagram

First Order: Open Coding **Based on interview data and literature.**	**Second Order: Axial Coding** **Identified CLD variables from interview data.**	**Third Order: Selective Coding** **Feedback look and casual links.**
B1 – Work Completion		
Converted Stocks & Flows to Causal Loop Diagram (Lyneis and Ford, 2007, Ford and Lyneis, 2020).	Variables: "Original Work to Do" "Project Progress"	Feedback loop: Original Work to Do (positive) → Project Progress (negative) → Original Work to Do

First Order: Open Coding **Based on interview data and literature.**	**Second Order: Axial Coding** **Identified CLD variables from interview data.**	**Third Order: Selective Coding** **Feedback look and casual links.**
B2 – Rework Completion		
Converted Stocks & Flows to Causal Loop Diagram (Lyneis and Ford, 2007, Ford and Lyneis, 2020).	Variables: "Rework to Do" "Project Progress"	Feedback loop: Rework to Do (positive) → Project Progress (negative) → Rework to Do
R1 – Rework Cycle		
Converted Stocks & Flows to Causal Loop Diagram (Lyneis and Ford, 2007, Ford and Lyneis, 2020).	Variables: "Rework Discovery" "Rework to Do" "Project Progress" "Error Generation" "Undiscovered Rework" "Rework Discovery"	Feedback loop: Rework Discovery (positive) → Rework to Do (positive) → Project Progress (positive) → Error Generation (positive) → Undiscovered Rework (positive) → Rework Discovery
R2 – AI Data Generation		
		Feedback loop: Project Data Generation (positive) → Trust in AI (positive) → Willingness to Take Corrective Action (positive) → Rework Discovery (positive) → Rework to Do (positive) → Project Progress (positive) → Project Data Generation
"As the project continues [project progress], the project generates new data [project data generation] and we can use the updated data to improve our model. We are then also able to improve the trust in the model [trust in AI model]." Participant 4	Variables: "Project Progress" "Project Data Generation" "Trust in AI Model"	Causal link: Project Progress (positive) → Project Data Generation (positive) → Trust in AI
"I want as much new data as possible in the AI model, the data used for planning is important, but using the new data [project data generation] makes me trust we use the most relevant data [trust in AI model]." "More current project data we use for the AI analysis [project data generation], means I will have in the model and I will be willing to act on the AI analysis [trust in AI model]." Participant 11		
"This is why we do our best prediction at the end of the project [project progress], then we have more reliable data [project data generation]. When the data is created we can make better predictions, i.e. also trust that the AI model perform well [trust in AI model]." Participant 18		
"Accurate reports where I am given the status of the project [project progress] are key for me to be able to make an educated decision whether the project needs correction [corrective action] or not. When I am given accurate reports based on current data [project data generation] I feel more confidence in the (AI) analysis [trust in AI model]." Participant 12		
"We wish we could report in a "live format" which would increase our reporting frequency. This would mean we would have more relevant		

First Order: Open Coding Based on interview data and literature.	Second Order: Axial Coding Identified CLD variables from interview data.	Third Order: Selective Coding Feedback look and casual links.
information. Now we have to settle with reporting as project goes on [project progress] and as close to "live" as possible, at least then we know we do the best we can and can train the AI model with newest data [project data generation] and trust the model [trust in AI model]." Participant 3		
"… the more trust I will have in the model [trust in AI model] and I will be willing to act on the AI analysis [willingness to take corrective action]." Participant 11	Variables: "Trust in AI Model" "Willingness to Take Corrective Action"	Causal link: Trust in AI Model (positive) → Willingness to Take Corrective Action
"If I trust the AI model [trust in AI model] and it recommends me to look at something, then I will be willing to follow its suggestion [willingness to take corrective action]." Participant 3		
"It is crucial I have an AI analysis that is accurate and the performance is trustworthy [trust in AI model], otherwise I would not use it and it would be a waste of time to use the AI. And of course it's the reverse that if I trust the model is performing well, then I will use its analysis. [willingness to take corrective action]" "Our sponsor or client will not accept us relocating resources [willingness to take corrective action] if the model is not used with confidence [trust in AI model], so essentially we all have to trust the model is giving us results we can use and trust." Participant 20		
"If I trust the AI model [trust in AI model] I feel more secure to take action and follow the recommendation [willingness to take corrective action]." Participant 18		
"Trusting the model [trust in AI model] is key, if my team doesn't trust the model it will not be possible to follow the analysis [willingness to take corrective action] if the model says the project is running behind." Participant 4		
"When we have less relevant project data, when we sit in meetings, people tend to question the AI model's outcome more [trust in AI model] [willingness to take corrective action]." Participant 15		
"I am encouraged by my senior sponsors to take corrective action, but prior to this I need to know the best option because there is no going back after making changes. I don't know what chain of reactions I will set in motion if I start to move resources around and so on [willingness to take corrective action]. Sometimes things sort out themselves and sometimes they don't. It all depends if we can rely on the AI [trust in AI model]." Participant 3		
"When I act on the warning sign [willingness to take corrective action], I then analyse what is required to do, where is the missing link and what do we need to do to fix it [rework discovery]." Participant 12	Variables: "Willingness to Take Corrective Action" "Rework Discovery"	Causal link: Willingness to Take Corrective Action (positive) → Rework Discovery (positive) → Rework to Do
"…if I am actively looking for rework and willing to stop the escalation [willingness to take corrective action] then I am more likely to find delays and tasks that need attention [rework discovery]." Participant 4		

First Order: Open Coding **Based on interview data and literature.**	**Second Order: Axial Coding** **Identified CLD variables from interview data.**	**Third Order: Selective Coding** **Feedback look and casual links.**
Converted Stocks & Flows to Causal Loop Diagram (Lyneis and Ford, 2007, Ford and Lyneis, 2020).	Variable: "Rework Discovery"	Causal link: Rework Discovery (positive) → Rework to Do (positive) → Project Progress
R3 – Trust in AI		
		Feedback loop: Trust in AI model (positive) → Willingness to Take Corrective Action (positive) → Rework Discovery (positive) → Project Data Generation (positive) → Trust in AI
"… the more trust I will have in the model [trust in AI model] and I will be willing to act on the AI analysis [willingness to take corrective action]." Participant 11	Variables: "Trust in AI Model" "Willingness to Take Corrective Action"	Causal link: Trust in AI Model (positive) → Willingness to Take Corrective Action
"If I trust the AI model [trust in AI model] and it recommends me to look at something, then I will be willing to follow its suggestion [willingness to take corrective action]." Participant 3		
"It is crucial I have an AI analysis that is accurate and the performance is trustworthy [trust in AI model], otherwise I would not use it and it would be a waste of time to use the AI. And of course it's the reverse that if I trust the model is performing well, then I will use its analysis. [willingness to take corrective action]" "Our sponsor or client will not accept us relocating resources [willingness to take corrective action] if the model is not used with confidence [trust in AI model], so essentially we all have to trust the model is giving us results we can use and trust." Participant 20		
"If I trust the AI model [trust in AI model] I feel more secure to take action and follow the recommendation [willingness to take corrective action]." "This [trust in AI model] can change as the project goes on, but I usually have my assumption from the planning stage [short term delay], and in the end it's dependent on if the team and I want take on plan B [willingness to take corrective action] [medium strength feedback]". Participant 18	(medium strength feedback) (short term delay)	
"Trusting the model [trust in AI model] is key, if my team doesn't trust the model it will not be possible to follow the analysis [willingness to take corrective action] if the model says the project is running behind." "It [trust in AI model] goes on constantly from the start [short term delay], but it is not the only thing that matters, my willingness to act and trust in the AI model weighs heavier [medium strength feedback]." Participant 4	(medium strength feedback) (short term delay)	
"When we have less relevant project data, when we sit in meetings, people tend to question the AI model's outcome more [trust in AI model] [willingness to take corrective action]." Participant 15		

First Order: Open Coding **Based on interview data and literature.**	**Second Order: Axial Coding** **Identified CLD variables from interview data.**	**Third Order: Selective Coding** **Feedback look and casual links.**
"I am encouraged by my senior sponsors to take corrective action, but prior to this I need to know the best option because there is no going back after making changes. I don't know what chain of reactions I will set in motion if I start to move resources around and so on [willingness to take corrective action]. Sometimes things sort out themselves and sometimes they don't. It all depends if we can rely on the AI [trust in AI model]." Participant 3		
"If I decide to follow the AI [willingness to take corrective action], I see what the issue is [rework discovery], at the same time the AI model learns constantly from the identified delays [project data generation] and will improve for next time." Participant 18	Variables: "Willingness to Take Corrective Action" "Rework Discovery" "Project Data Generation"	Causal link: Willingness to Take Corrective Action (positive) → Rework Discovery (positive) → Project Data Generation
"When I act on the warning sign [willingness to take corrective action], I then analyse what is required to do, where is the missing link and what do we need to do to fix it [rework discovery]. This generates more data [project data generation] for the AI model to learn from." Participant 12		
"I am actually happy when we find delays and tasks that need redoing [willingness to take corrective action] [rework discovery], this means that we do a good job and it creates more training data [project data generation]." Participant 4		
"The sooner the quality team and I find tasks that are not up to standard [rework discovery] we can improve the project, and it we can learn from our mistakes. When we have delays, more data is generated [project data generation]. It can be seen as a win-win to improve." Participant 15		
"As the project continues, the project generates new data [project data generation] and we can use the updated data to improve our model. We are then also able to improve the trust in the model [trust in AI model]." Participant 4	Variables: "Project Data Generation" "Trust in AI Model"	Causal link: Project Data Generation (positive) → Trust in AI Model
"I want as much new data as possible in the AI model, the data used for planning is important, but using the new data [project data generation] makes me trust we use the most relevant data [trust in AI model]." "More current project data we use for the AI analysis [project data generation], means I will have in the model and I will be willing to act on the AI analysis [trust in AI model]." Participant 11		
"This is why we do our best prediction at the end of the project, then we have more reliable data [project data generation]. When the data is created we can make better predictions, i.e. also trust that the AI model perform well [trust in AI model]." Participant 18		
"Accurate reports where I am given the status of the project are key for me to be able to make an educated decision whether the project needs correction [corrective action] or not. When I am given accurate reports based on current data [project data generation] I feel more confidence in the (AI) analysis [trust in AI model]." Participant 12		

First Order: Open Coding Based on interview data and literature.	Second Order: Axial Coding Identified CLD variables from interview data.	Third Order: Selective Coding Feedback look and casual links.
"We wish we could report in a "live format" which would increase our reporting frequency. This would mean we would have more relevant information. Now we have to settle with reporting as project goes on and as close to "live" as possible, at least then we know we do the best we can and can train the AI model with newest data [project data generation] and trust the model [trust in AI model]." Participant 3		
R4 – Willingness to Use AI		
		Feedback loop: Willingness to Take Corrective Action (positive) → Trust in AI (positive) → Willingness to Take Corrective Action
"I feel that the more I am willing to act according to the warning sign [willingness to take corrective action], the more I will trust the model [trust in AI model]. This is good as long as the AI performs well, it can be vicious cycle if I trust the model and it starts to make poor suggestions." "When I finally decide to act [long term delay] on the warning sign we have to act fast and accurate, it overruns other factors such as the trust in the model and not willing to take corrective action [strong feedback]." Participant 4	Variables: "Willingness to Take Corrective Action" "Trust in AI Model" (strong feedback) (long term delay)	Causal link: Willingness to Take Corrective Action (positive) → Trust in AI Model (positive) → Willingness to Take Corrective Action
"… the more trust I will have in the model [trust in AI model] and I will be willing to act on the AI analysis [willingness to take corrective action]." Participant 11		
"If I trust the AI model [trust in AI model] and it recommends me to look at something, then I will be willing to follow its suggestion [willingness to take corrective action]." "This [willingness to take corrective action] has a strong influence on the final decision [strong feedback], and it can take a long time [long term delay]." Participant 3	(strong feedback) (long term delay)	
"It is crucial I have an AI analysis that is accurate and the performance is trustworthy [trust in AI model], otherwise I would not use it and it would be a waste of time to use the AI. And of course it's the reverse that if I trust the model is performing well, then I will use its analysis. [willingness to take corrective action]" "Our sponsor or client will not accept us relocating resources [willingness to take corrective action] if the model is not used with confidence [trust in AI model], so essentially we all have to trust the model is giving us results we can use and trust." Participant 20		
"If I trust the AI model [trust in AI model] I feel more secure to take action and follow the recommendation [willingness to take corrective action]." Participant 18		
"Trusting the model [trust in AI model] is key, if my team doesn't trust the model it will not be possible to follow the analysis [willingness to take		

First Order: Open Coding Based on interview data and literature.	Second Order: Axial Coding Identified CLD variables from interview data.	Third Order: Selective Coding Feedback look and casual links.
corrective action] if the model says the project is running behind." Participant 4		
"When we have less relevant project data, when we sit in meetings, people tend to question the AI model's outcome more [trust in AI model] [willingness to take corrective action]." Participant 15		
"I am encouraged by my senior sponsors to take corrective action, but prior to this I need to know the best option because there is no going back after making changes. I don't know what chain of reactions I will set in motion if I start to move resources around and so on [willingness to take corrective action]. Sometimes things sort out themselves and sometimes they don't. It all depends if we can rely on the AI [trust in AI model]." Participant 3		
R5 – Anchoring to Data		
		Feedback loop: Cognitive Anchor to Data (negative) → Confidence in Original Project Plan (positive) → Escalation of Commitment (negative) → Willingness to Take Corrective Action (positive) → Rework Discovery (positive) → Project Data Generation (positive) → Cognitive Anchor to Data
"I believe the generated data [project data generation] is more accurate to use than the data we used during the planning phase [cognitive anchor to data]." "This [project generated data] becomes real [cognitive anchor to data] for me after a while, the project has to run for a little while before I can rely on it [medium term delay]." "Just as the trust in the model, this can be overturned by other feedbacks related to my willingness to act [medium strength feedback]". Participant 4	Variables: "Project Data Generation" "Cognitive Anchor to Data" (medium strength feedback) (medium term delay)	Causal link: Project Data Generation (positive) → Cognitive Anchor to Project Plan
"I rather use the data that is created during the project [project data generation], than data that feels outdated [cognitive anchor to data]." Participant 11		
"So if I have to choose between historical and more recent data [project data generation], I rather feed the AI model with the data from the actual project [cognitive anchor to data]." "I wouldn't say this is the strongest feedback, but in the middle [medium strength feedback], same regarding when it happens [medium term delay]." Participant 6	(medium strength feedback) (medium term delay)	
"This will lead to that I am willing to change the project plan [confidence in original project plan] as new data is created [cognitive anchor to data]." Participant 6	Variables: "Cognitive Anchor to Data" "Confidence in Original Project Plan"	Causal link: Cognitive Anchor to Data (negative) → Confidence in Original Project Plan

First Order: Open Coding **Based on interview data and literature.**	**Second Order: Axial Coding** **Identified CLD variables from interview data.**	**Third Order: Selective Coding** **Feedback look and casual links.**
"I have to adopt and adjust the project when we have new information [cognitive anchor to data], and yes I will, if necessary, change the set project plan [confidence in original project plan]." Participant 11		
"If I have confidence in that the project plan is well made [confidence in original project plan], then I will probably have more reluctance to do anything about it. I would then want to give it (the project) some more time [escalation of commitment]." Participant 11	Variables: "Confidence in Original Project Plan" "Escalation of Commitment"	Causal link: Confidence in Original Project Plan (positive) → Escalation of Commitment
"A factor to not make changes to the project [escalation of commitment] is that the team still believes the project plan is viable [confidence in original project plan]." Participant 6		
"I feel that I can justify to wait out the problem [escalation of commitment] because it is the default stage if I have confidence in the project plan [confidence in original project plan]." Participant 4		
"What is to say that the project plan is not correct [confidence in original project plan]? Circumstances will always change and the original project plan can still be the best option for us. If we wait out the situation it might be in favour for us [escalation of commitment]." Participant 3		
"Sometimes we make decisions in an emotional state and it seems as we are looking for any excuse to change the plan [confidence in original project plan], well actually, doing nothing is also doing something [escalation of commitment]. Sometimes the circumstances change in our favour." Participant 12		
"I know that my project will see some kind of escalation, and it will at first make me hesitant to act[willingness to take corrective action], I know this is a bias all project managers are likely to have, me included [escalation of commitment]." Participant 12	Variables: "Escalation of Commitment" "Willingness to Take Corrective Action"	Causal link: Escalation of Commitment (negative) → Willingness to Take Corrective Action"
"It is obvious that when the project is escalating, it is easier to not do anything at first [escalation of commitment], it takes usually more guts to interrupt the progress of the project [willingness to take corrective action]." Participant 6		
"If I decide to follow the AI [willingness to take corrective action], I see what the issue is [rework discovery], at the same time the AI model learns constantly from the identified delays [project data generation] and will improve for next time." Participant 18	Variables: "Willingness to Take Corrective Action" "Rework Discovery" "Project Data Generation"	Causal link: Willingness to Take Corrective Action (positive) → Rework Discovery (positive) → Project Data Generation
"When I act on the warning sign [willingness to take corrective action], I then analyse what is required to do, where is the missing link and what do we need to do to fix it [rework discovery]. This generates more data [project data generation] for the AI model to learn from." Participant 12		
"I am actually happy when we find delays and tasks that need redoing [willingness to take corrective action] [rework discovery], this means		

First Order: Open Coding Based on interview data and literature.	Second Order: Axial Coding Identified CLD variables from interview data.	Third Order: Selective Coding Feedback look and casual links.
that we do a good job and it creates more training data [project data generation].” Participant 4		
“The sooner the quality team and I find tasks that are not up to standard [rework discovery] we can improve the project, and it we can learn from our mistakes. When we have delays, more data is generated [project data generation]. It can be seen as a win-win to improve.” Participant 15		
R6 – The Wait Effect		
		Feedback loop: Confidence in Original Project Plan (positive) → Escalation of Commitment (negative) → Willingness to Take Corrective Action (positive) → Rework Discovery (positive) → Rework to Do (positive) → Project Progress (positive) → Project Data Generation (positive) → Cognitive Anchor to Data (negative) → Confidence in Original Project Plan
“If I have confidence in that the project plan is well made [confidence in original project plan], then I will probably have more reluctance to do anything about it. I would then want to give it (the project) some more time [escalation of commitment].” Participant 11	Variables: “Confidence in Original Project Plan” “Escalation of Commitment”	Causal link: Confidence in Original Project Plan (positive) → Escalation of Commitment
“A factor to not make changes to the project [escalation of commitment] is that the team still believes the project plan is viable [confidence in original project plan]." “It’s related to both willingness make correction [willingness to take corrective action] and the confidence in the plan [confidence in original project plan], it can take a long time to take action [willingness to take corrective action], since it is my first assumption [short term delay], and difficult to change [strong feedback] but when it happens [willingness to take corrective action] it will go fast.” Participant 6	(strong feedback) (short term delay)	
“I feel that I can justify to wait out the problem [escalation of commitment] because it is the default stage [short term delay] if I have confidence in the project plan [confidence in original project plan].” “It will require quite a lot of evidence to finally act on the warning sign [strong feedback]”. Participant 4	(strong feedback) (short term delay)	
“What is to say that the project plan is not correct [confidence in original project plan]? Circumstances will always change and the original project plan can still be the best option for us. If we wait out the situation it might be in favour for us [escalation of commitment].” Participant 3		
“Sometimes we make decisions in an emotional state and it seems as we are looking for any excuse to change the plan [confidence in original project plan], well actually, doing nothing is also doing something [escalation of commitment].		

First Order: Open Coding **Based on interview data and literature.**	**Second Order: Axial Coding** **Identified CLD variables from interview data.**	**Third Order: Selective Coding** **Feedback look and casual links.**
Sometimes the circumstances change in our favour." Participant 12		
"I know that my project will see some kind of escalation, and it will at first make me hesitant to act[willingness to take corrective action], I know this is a bias all project managers are likely to have, me included [escalation of commitment]." Participant 12	Variables: "Escalation of Commitment" "Willingness to Take Corrective Action"	Causal link: Escalation of Commitment (negative) → Willingness to Take Corrective Action"
"It is obvious that when the project is escalating, it is easier to not do anything at first [escalation of commitment], it takes usually more guts to interrupt the progress of the project [willingness to take corrective action]." Participant 6		
"When I act on the warning sign [willingness to take corrective action], I then analyse what is required to do, where is the missing link and what do we need to do to fix it [rework discovery]." Participant 12	Variables: "Willingness to Take Corrective Action" "Rework Discovery"	Causal link: Willingness to Take Corrective Action (positive) → Rework Discovery (positive) → Rework to Do
"…if I am actively looking for rework and willing to stop the escalation [willingness to take corrective action] then I am more likely to find delays and tasks that need attention [rework discovery]." Participant 4		
Converted Stocks & Flows to Causal Loop Diagram (Lyneis and Ford, 2007, Ford and Lyneis, 2020).	Variable: "Rework Discovery"	Causal link: Rework Discovery (positive) → Rework to Do (positive) → Project Progress
"As the project continues [project progress], the project generates new data [project data generation] and we can use the updated data to improve our model." Participant 4	Variables: "Project Progress" "Project Data Generation"	Causal link: Project Progress (positive) → Project Data Generation
"We wish we could report in a "live format" which would increase our reporting frequency. This would mean we would have more relevant information. Now we have to settle with reporting as project goes on [project progress] and as close to "live" as possible, at least then we know we do the best we can and can train the AI model with newest data [project data generation]…" Participant 3		
"I believe the generated data [project data generation] is more accurate to use than the data we used during the planning phase [cognitive anchor to data]." Participant 4	Variables: "Project Data Generation" "Cognitive Anchor to Data"	Causal link: Project Data Generation (positive) → Cognitive Anchor to Project Plan
"I rather use the data that is created during the project [project data generation], than data that feels outdated [cognitive anchor to data]." Participant 11		
"So if I have to choose between historical and more recent data [project data generation], I rather feed the AI model with the data from the actual project [cognitive anchor to data]." Participant 6		
"This will lead to that I am willing to change the project plan [confidence in original project plan] as new data is created [cognitive anchor to data]." Participant 6	Variables: "Cognitive Anchor to Data" "Confidence in Original Project Plan"	Causal link: Cognitive Anchor to Data (negative) → Confidence in Original Project Plan =

First Order: Open Coding **Based on interview data and literature.**	**Second Order: Axial Coding** **Identified CLD variables from interview data.**	**Third Order: Selective Coding** **Feedback look and casual links.**
"I have to adopt and adjust the project when we have new information [cognitive anchor to data], and yes I will, if necessary, change the set project plan [confidence in original project plan]." Participant 11		
Constant variables		
"Sometimes I just feel the project is too unique [project uniqueness perception] and it will be challenging for the AI to make sense of the data [trust in AI model]." Participant 4	Constant variable: "Project Uniqueness Perception" Variable: "Trust in AI Model"	Causal link: Project Uniqueness Perception (negative) → Trust in AI Model
"I see myself and others have a tendency to believe the project we are working on is special, it's our little baby [project uniqueness perception], and is sometimes used as an argument not to trust the AI performance [trust in AI model]." Participant 3		
"There are some unique areas in every project, sometimes the team and I overestimate the value of these unique traits [project uniqueness perception], sometimes we don't, but when we do it affects how we interact with the AI and if we can be sure its fed with relevant data so we can trust it [trust in AI model]." Participant 11		
"We have learnt that all projects are unique [project uniqueness perception], and its true to some extent, this perception makes me question what data is fed to the model [trust in AI model] and if the model's output is useful or not." Participant 12		
"When we have less relevant project data [project uniqueness perception], when we sit in meetings, people tend to question the AI model's outcome more [trust in AI model]." Participant 15		
"The unique traits of a project make me believe that the project plan is solid [confidence in original project plan], because there won't be many other projects that we can reuse data or previous projects to learn from [project uniqueness perception]." Participant 3	Constant variable: "Project Uniqueness Perception" Variable: "Confidence in Original Project Plan"	Causal link: Project Uniqueness Perception (positive) → Confidence in Original Project Plan
"We usually spend a lot of time planning a project, and my confidence in the plan depends on how well we did the planning. If it is a very unique project, not much new data will help coming up with a better plan [project uniqueness perception], the new plan will be just as good as the original one. I will still believe the original plan is just as good [confidence in original project plan]." Participant 4		
"When we have less relevant project data [project uniqueness perception], when we sit in meetings, people tend to question the AI model's outcome more. And rely on our set plan instead [confidence in original project plan]." Participant 15		
"It's like if someone shows you a plan and all the proof and background information for why that plan is the best option, if I am able to see this from the AI [AI explainability], I am more likely to trust	Constant variable: "AI Explainability" Variable: "Trust in AI Model"	Causal link: AI Explainability (positive) → Trust in AI Model

First Order: Open Coding Based on interview data and literature.	Second Order: Axial Coding Identified CLD variables from interview data.	Third Order: Selective Coding Feedback look and casual links.
that the AI suggestion is good [trust in AI model]." Participant 4		
"It's quite evident that if the AI offers an explanation [AI explainability] of high quality I will be able to trust it is telling the truth [trust in AI model]…" Participant 12		
"The better the explanation is [AI explainability] the more I can believe its output is correct [trust in AI model]." "The reason for why or why not I am trusting the model [trust in AI model] can be based on many different things, being able to explain the model is a major factor [AI explainability]." Participant 11		
"If we use a machine learning model we are probably going to get very good analysis, but unfortunately we won't be able to understand why or on what premise the AI suggests its analysis because the understanding [AI explainability] of the model is low. Instead we can use a less advanced AI but will understand it instead, sometimes there are benefits of using one or the other, if I can understand it I will also trust it [trust in AI model]." Participant 3		
"When my team can make sense of the AI model output, and also explain this to my senior management [AI explainability], then I feel more support from my management colleagues [trust in AI model]." Participant 18		
"It doesn't matter much if I understand the AI model if I can't convince my team members what is happening in the project [AI explainability]. Because I am accountable in the end. In some projects, the sponsor has not understood the deep learning model which has created some upsetting scenes when the project didn't turn out the way we wanted. This has led us to use perhaps simpler models where we can point at the fault in the AI model. This affects the trust in the model [trust in AI model]." Participant 20		

5.6 Results

5.6.1 Causal loop diagram

We demonstrate our findings through eight feedback loops and build our full CLD model step by step, presented in Figure 13. The CLD adopts "the rework cycle", which explains how project work moves from "original work to do" to "work done" as the basis for depicting the behaviour of projects (Cooper, 1993b, Ford and Lyneis, 2020, Lyneis and Ford, 2007). "Rework" is an established metric for measuring project progress (Cooper, 1993a, Ford and Lyneis, 2020, Jalili and Ford, 2016, Khatun et al., 2023, Love et al., 2002, Love et al., 2023, Lyneis and Ford, 2007, Rahmandad and Hu, 2010).

Figure 11 consists of three feedback loops representing a project's progress and rework. The balancing loop "B1 - Work Completion" demonstrates how the variable "original work to do" increases "project progress", which in turn decreases the former. The second balancing loop, "B2 - Rework Completion", includes "project progress" with a negative impact on "rework to do", followed by a positive impact on the former. Further on, the loop "R1 - Rework Cycle" represents the creation of rework through positive causal effects on the variables "project progress", "error generation", "undiscovered rework", "rework discovery", "rework to do", and "project progress". The completed project work is represented by "work done".

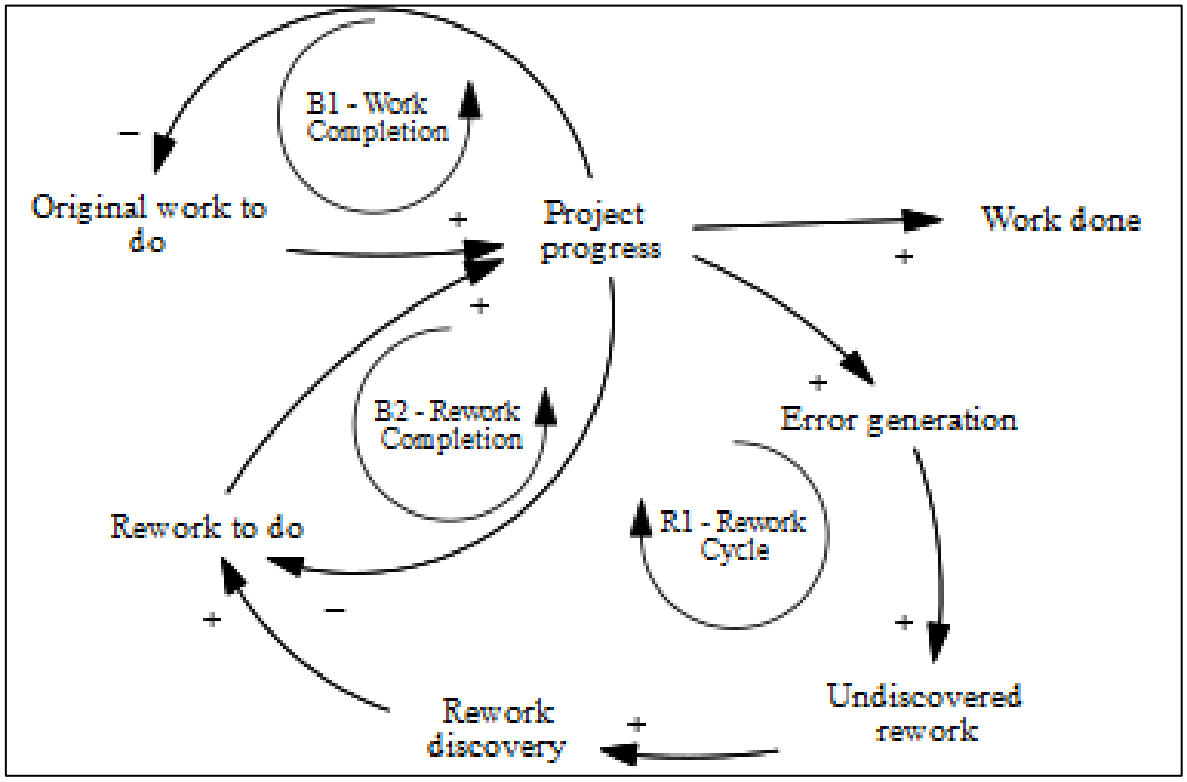

Figure 11: Feedback loops "B1 - Work Completion", "B2 - Rework Completion", "R1 - Rework Cycle"

Adding two reinforcing feedback loops in Figure 12. The loop "R2 – AI Data Generation" includes positive causal effects on the variables "project progress", "project data generation", and "trust in AI model". The positive impact on trust in AI is based on the data collection where more data is assumed to lead to a higher accuracy in the AI model's output. Further on, the positive causal links move through "trust in AI", "willingness to take corrective action", "rework discovery", "rework to do" and "project progress". Loop "R3 - Trust in AI" represents the reinforcing trust in the AI model through the positive links "trust in AI model", "willingness to take corrective action", "rework discovery", "project data generation", and "trust in AI model". Our research suggests that the variable "trust in AI model" is influenced by the constants "project uniqueness perception" and "AI explainability". Managers believe that the uniqueness of a project negatively affects the "trust in AI model" and state that an AI will not perform well if insufficient

data is used or the project is perceived as unique in its characteristics, leading to a negative impact on trust. We include “AI explainability” as a constant variable representing the project manager's sufficient level of explainability leading to an increase in the AI model.

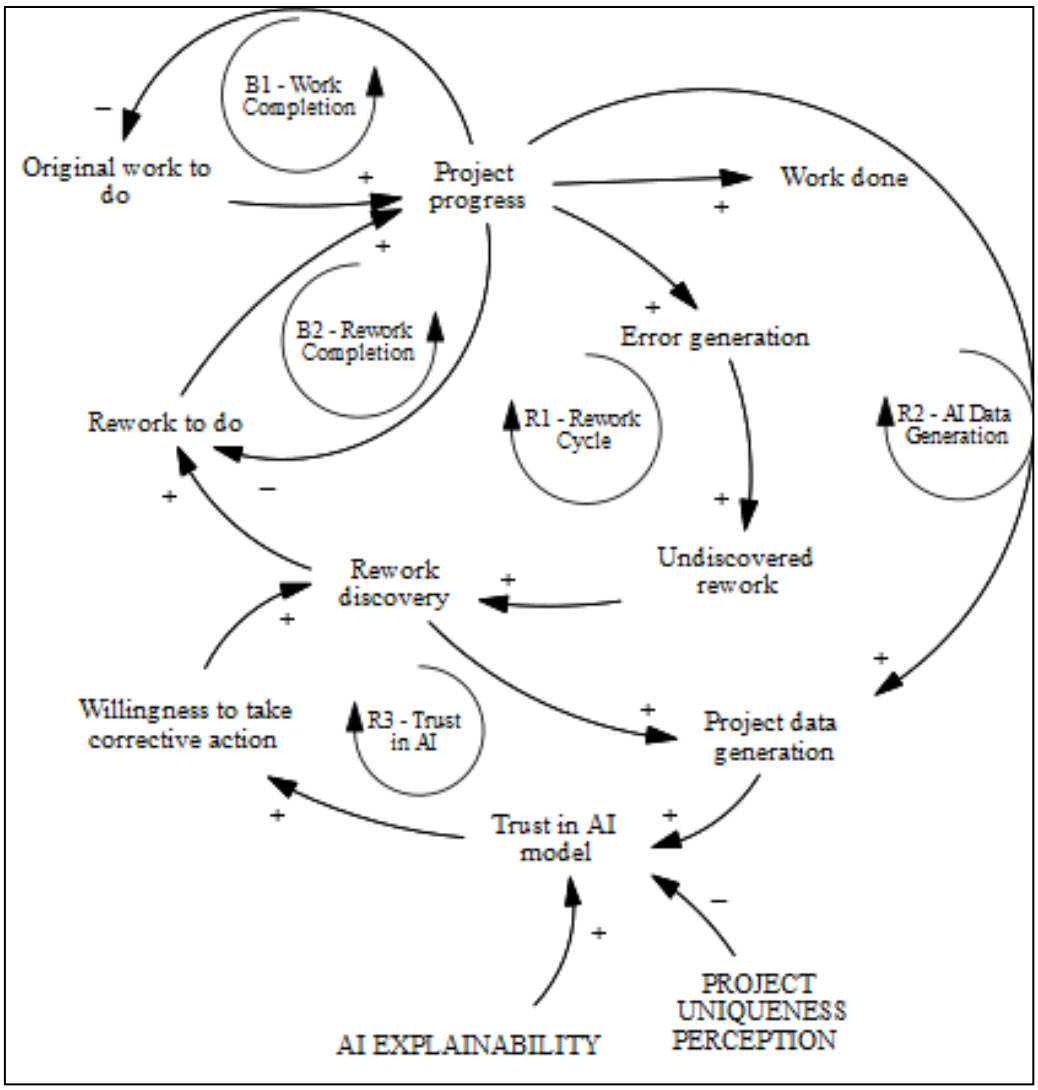

Figure 12: Added feedback loops: “R2 - AI Data Generation”, “R3 - Trust in AI”

The full CLD model is presented in Figure 13. The loop “R4 - Willingness to Use AI” consists of the positive influences from the variables “willingness to take corrective action” and “”trust in AI model”. Loop “R5 - Anchoring to Data” begins with a negative influence from “cognitive anchor to data” to “confidence in original project plan”, followed by positive impact on “escalation of commitment”, and a decrease in “willingness to take corrective action”. The remaining variables have positive influences on “rework discovery”, “project data generation”, and “cognitive anchor to data”. The final loop is named “R6 - The Wait Effect”, which is the main contribution of our research. The causal chain is mentioned through previous loops through “escalation of commitment”, “willingness to take corrective action”, “rework discovery”, “rework to do”, “project progress”, “project data generation”, “cognitive anchor to data”, “confidence in original project plan”, and “escalation of commitment”. “The wait effect” is

represented through “confidence in original project plan” increases project managers’ EoC which in turn decreases “willingess to take corrective action”.

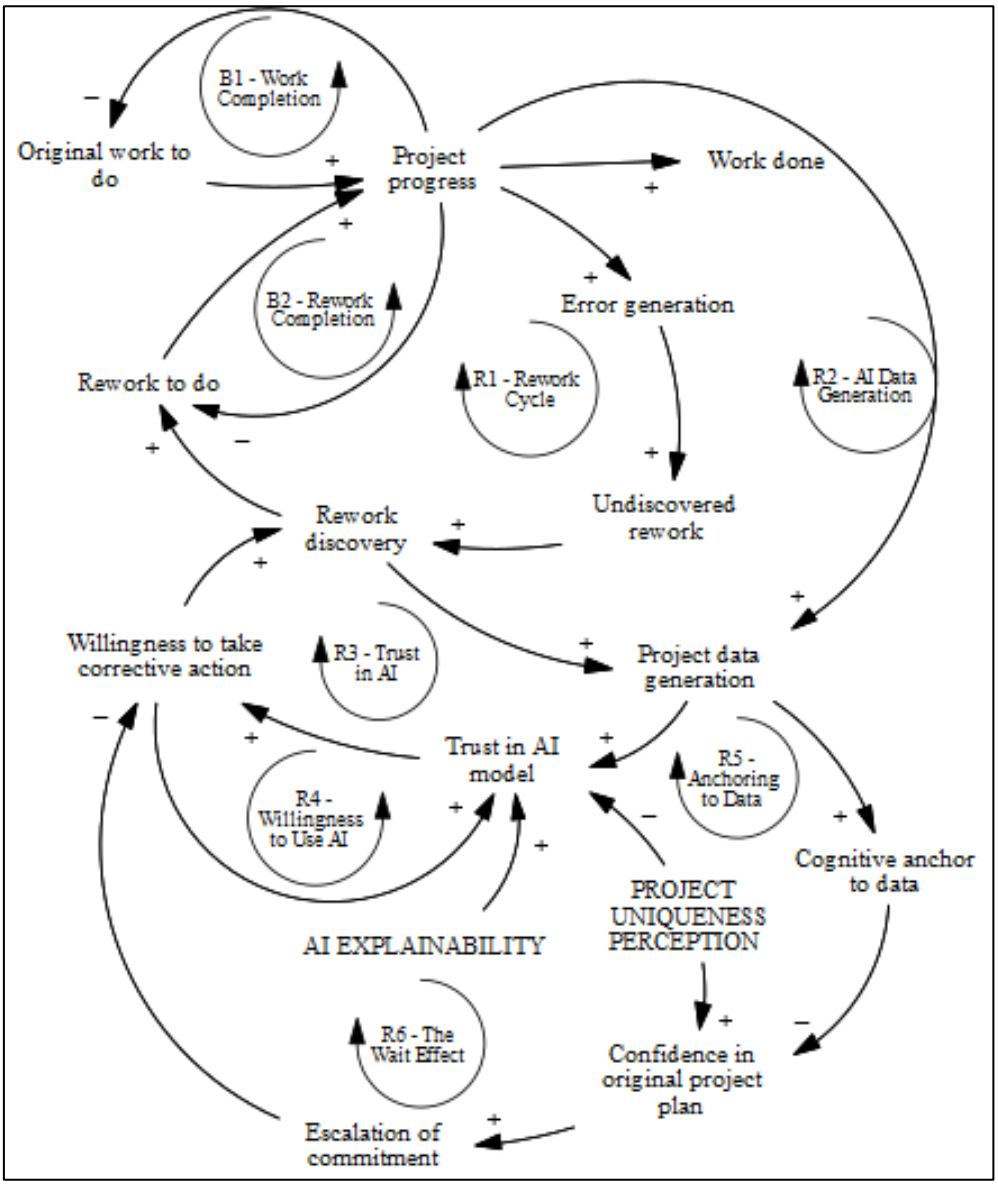

Figure 13: Added feedback loops: “R5 - Anchoring to Data”, “R6 - The Wait Effect”

The feedback loops R3, R4, R5, and R6 are the main part of our research contribution, and we explain them further in Table 16. We define the loops according to time delay (short, medium, or long-term), and strength of feedback (weak, medium, or strong). Short-term delay represents little to no time delay. This type of feedback is active from the start of the behavioural model, whereas long-term delay is significant delayed feedback. Medium delay represents feedback that is not active from the start but is activated once after the short-term feedback loops. The strengths of the feedback loops describe which loop overtakes the others. We present interview data justifying the definitions of the loops in Table 16.

Table 16: Summary of all feedback loops of the wait effect CLD

Feedback loops	Characteristics (feedback strength and time delay)	Interview data explaining feedback strength and time delay
R3 - Trust in AI	Medium strength feedback Short term delay	"This [trust in AI model] can change as the project goes on, but I usually have my assumption from the planning stage [short term delay], and in the end it's dependent on if the team and I want take on plan B [willingness to take corrective action] [medium strength feedback]". Participant 18 "It [trust in AI model] goes on constantly from the start [short term delay], but it is not the only thing that matters, my willingness to act and trust in the AI model weighs heavier [medium strength feedback]." Participant 4
R4 - Willingness to Use AI	Strong feedback process Long term delay	"This [willingness to take corrective action] has a strong influence on the final decision [strong feedback], and it can take a long time [long term delay]." Participant 3 "When I finally decide to act [long term delay] on the warning sign we have to act fast and accurate, it overruns other factors such as the trust in the model and not willing to take corrective action [strong feedback]." Participant 4
R5 - Anchoring to Data	Medium strength feedback process Medium term delay	"This [project generated data] becomes real [cognitive anchor to data] for me after a while, the project has to run for a little while before I can rely on it [medium term delay]." "Just as the trust in the model, this can be overturned by other feedbacks related to my willingness to act [medium strength feedback]". Participant 4
R6 - The Wait Effect	Strong feedback process Short term delay	"It's related to both willingness make correction [willingness to take corrective action] and the confidence in the plan [confidence in original project plan], it can take a long time to take action [willingness to take corrective action], since it is my first assumption [short term delay], and difficult to change [strong feedback] but when it happens [willingness to take corrective action] it." Participant 6

5.7 Discussion

Our research studied project managers' behaviour when using AI tools during project control through the lens of BOR. As part of OR, project management has benefited significantly from optimisation capabilities in analytical tools (Tavares, 2002), and the impact of AI tools in OR has been discussed for a significant time (Hendry, 1987, Pomerol, 1997, Rosenthal-Sabroux and Zaraté, 1997). BOR provides a substantial addition to the OR field as it enables to study the behavioural aspects of OR tools (Hämäläinen et al., 2013, Keller and Katsikopoulos, 2016, White et al., 2020, Wang et al., 2020b). Thus, we used the lens of BOR to answer the following research question: *How do behavioural theories or constructs affect project managers during the project control process when using Artificial Intelligence technology as early warning sign tools?* We answer this research question and discuss our findings in the following sections.

5.7.1 The Wait Effect

The premise of our research is based on an AI model increasing the efficiency of project rework discovery through warning signs indicating when corrective action is needed. As the time to

discover project rework is reduced, the project can avoid schedule delays and budget overruns. Our research findings and CLD model, see Figure 13, suggest that managers can either ignore the AI warning sign by escalating the project based on their confidence in the original project plan (feedback loop "R6 - The Wait Effect"), or take corrective action based on trust in the AI model (feedback loop "R4 - Willingness to Use AI"). We find project managers' willingness to take corrective action is influenced by EoC behaviour and the trust in the AI model, which in turn are affected by the perception of projects being a unique endeavour, the willingness to take corrective action, AI explainability, and project data generation. Low willingness to take corrective action leads to our main research contribution, the behaviour "the wait effect", which makes EoC behaviour continue regardless of AI warning signs. We propose that using project control tools based on AI create new behavioural biases, which is a significant contribution to BOR and EoC literature. The following sections discuss significant feedback loops and variables affecting the wait effect.

5.7.1.1 Escalation of Commitment

We presented the literature of EoC behaviour through prospect theory, optimism bias, completion effect, and goal incongruence. These constructs are significant during project control (Keil et al., 2000, Son and Rojas, 2011, Wang et al., 2017, Wang et al., 2020b, Winch, 2013). As the main contribution from our research, we suggest the behavioural construct of "the wait effect" to have a critical role in project managers' decision-making when using AI as an early warning system. Further on, this construct is a counter-intuitive behaviour where the manager hesitates to act on the AI warning sign. The project manager experiences a passive behaviour and acts according to EoC, delaying mitigation action. This passive behaviour is observed in the "action-inaction" literature by Feldman and Wong (2018), and we see similar behaviour in our research.

5.7.1.2 Trust in AI

The literature suggests trust in AI is based on factors such as fairness, accountability, transparency and explainability (Shin, 2020). Other researchers suggest factors of trustworthiness, causality and confidence (Barredo Arrieta et al., 2020). Aligned with the literature, we found AI explainability to be critical for project managers' trust in AI.

5.7.1.2.1 AI Explainability

The OR field benefits from De Bock et al. (2024) proposal referring to XAI through performance, attributable, and responsible analytics. Our research findings related to AI trust fall under attributable analytics, where we find a significant dependency between trust and XAI (Doshi-

Velez and Kim, 2018). Additionally, we find trustworthiness and confidence are linked to explainability (Barredo Arrieta et al., 2020). Aligned with the literature, we suggest the level of AI explainability increases the trust, and the user's ability to interpret the model (Hoffman et al., 2018). All of the interview participants used an AI black-box model, or a combination of a black-box model with a complementing interpretable model for their analysis. We recommend future research to focus on explainability and study what specific factors are found within XAI and projects.

5.7.1.2.2 Willingness to Take Action & Project Data Generation

We suggest the variables willingness to take corrective action, and project data generation to increase trust in AI. In our CLD model the willingness to take corrective action is low, triggering "the wait effect". Project data generation represents the data created during the project and we suggest that if data from the actual project is used to train the AI model, the trust of the AI increases. The literature suggest it is significant for managers to have the correct understanding of the AI model, as an incorrect trust in AI will cause an overuse or disuse of the AI model (Hoff and Bashir, 2015).We invite to further study how project data impacts managers' trust in AI.

Although Wang et al. (2020b) suggest the behaviour within reporting activities separates from project control, we found that reporting represented by the variable project data generation, is a key factor in the dynamics of the control process. In our CLD model, data generation is used to compare actual performance with project baseline standards (Olawale and Sun, 2013).

Additionally, we find that project managers tend to anchor their decisions to the generated project data which decreases the confidence in the original set project plan. This is an emotional attachment making decision-makers ignore statistical probabilities (Lovallo and Kahneman, 2003, Son and Rojas, 2011). Our research suggests that cognitive anchoring to the most recent project data decreases confidence in the original project plan with an enhanced effect on EoC. We argue that anchoring is added to project managers' behavioural constructs during project control rather than being placed within the project planning process (Wang et al., 2020b).

5.7.1.2.3 Project Uniqueness

We find project uniqueness to have a negative impact on AI trust. It is an established definition in the project community that projects are defined as unique endeavours (Turner and Müller, 2003). Vanhoucke et al. (2016) argue that having project data effectively reduces costs and delays, however, the authors also state the challenge of reusing data for multiple projects due to the perception of "uniqueness" creates non-reusable data. We argue that the perception of

project uniqueness is a significant heuristic among project managers when using AI models and we suggest project managers' perception of unique project data decreases trust in AI models. This is aligned with the project literature (Flyvbjerg, 2021). The negative effect on trust in AI may be reduced by improved data management processes such as the previously mentioned variable project data generation. We suggest future research on this topic and to challenge the perception of project uniqueness among managers.

5.8 Future Research and Limitations

We suggest studying AI in OR through XAI based on performance, attributable, and responsible analytics as suggested by De Bock et al. (2024). Beyond this, we believe it is interesting to understand OR through AI and quantum computing (Gupta et al., 2022). Future research should expand on the argument that stakeholders' perceptions of explainability can vary and study stakeholders' different preferences for XAI when using AI models (Langer et al., 2021). Our findings are cross-industry, and we realise the need for more specific case studies where managers use project data and AI. It is important to test our findings in a specific context and use all tools and methods suggested in BOR to evaluate the behaviour with, and beyond AI (White et al., 2020).

5.9 Conclusion

This research studied project managers' behaviour when applying AI for project control analysis and demonstrated this through qualitative CLD modelling. We studied project managers under the premise that an AI analysis tool is used as an early warning system to improve efficiency by reducing the time for rework discovery. The research identified feedback loops providing insights on managers' bias towards EoC.

The research provides three main contributions: 1) The key contribution is our proposal of the behavioural construct "the wait effect". This construct explains project managers' behaviour of EoC due to low willingness to take corrective action regardless of early warning signs from an AI model based on low trust in the AI. Additionally, managers' EoC behaviour based on confidence in the original project plan is suggested to decrease the willingness to take corrective action. We propose "the wait effect" enhances EoC, and for this bias to have a significant role in managers' decision-making process when using AI analysis during project control. It is a significant contribution to BOR and EoC literature.

2) The second contribution is a systemic understanding of what affects project managers' willingness to take corrective action during project control through the literature review and our

findings. We identified that trust in AI is critical for managers' ambitions to take corrective actions. Additionally, we found the variable trust in AI is increased by the factors of project data generation and AI explainability. Using relevant project data and having acceptable AI explainability creates a sense of trust among managers.

3) The third contribution is project managers' heuristic to view projects as "unique endeavours", where the perception of having unique project data decreases trust in AI and increases the confidence in the project plan leading to EoC.

To summarise, the use of AI is beneficial for project control analysis, however, it brings behavioural challenges which are in need of further research.

Chapter 6 Third Research Paper

Title: Exploring Project Managers' Heuristics: Mitigating De-Escalation Biases during Artificial Intelligence Analysis

Abstract

Researching the impact of Artificial Intelligence (AI) on project managers' decision-making processes during project escalation is significant. The phenomenon of Escalation of Commitment has been extensively studied, whereas De-escalation of Commitment (DoC) when managers take corrective action is still to receive equal attention. This study delves into managers' decision-making processes when facing project escalation and utilising AI analysis as an early warning system. Through interviews with 22 project managers experienced in using AI analysis during project control, our research reveals a bias we term "Override AI". The proposed bias construct promotes DoC behaviour. Furthermore, we identify that this bias is influenced by specific variables such as AI explainability, project uniqueness, and information asymmetry.

Keywords: project management, artificial intelligence; project escalation; de-escalation of commitment; escalation of commitment; project bias

6.1 Introduction

Artificial Intelligence (AI) is suggested to redefine business management (Davenport and Ronanki, 2018, Kolbjørnsrud et al., 2016, Wilson and Daugherty, 2018) and its industry development is suggested to race ahead of academia (Maslej et al., 2023). Hence, it is critical for academics to research the impact of AI on management decision-making. The role of AI systems in business organisations is a highly contemporary research area. Literature reviews demonstrate that AI and related data research fields are significant within project research (Dwivedi et al., 2021, Kiani, 2024b, Cubric, 2020, Enholm et al., 2022). Project management is an area where AI has the potential to improve current processes and decision-making (Duan et al., 2019, Cubric, 2020, Pellerin and Perrier, 2019). The combination of human and algorithm decision-making is suggested to outperform the lone human decision-maker and the single algorithm decision-tool (Burton et al., 2020, Jarrahi et al., 2023, Revilla et al., 2023). However, the literature on decision-making in projects using AI-based decision support systems is at a novel stage.

AI systems can potentially increase the quality of early warning signals (Hazır, 2015, Pellerin and Perrier, 2019). However, the project literature suggests that managers have cognitive barriers when responding to early warning signs (Haji-Kazemi et al., 2015, Benschop et al., 2020b). Effective early warning sign processes are critical identifying project escalation and is a complex activity where researchers explain project managers' biased behaviour through the concepts of Escalation of Commitment (EoC) and De-escalation of Commitment (DoC) (Yang et al., 2023, Ohlert and Weißenberger, 2020, Lee et al., 2018, Pan et al., 2006, Wang et al., 2020b, Keil and Robey, 1999).

Our research studies project managers' behaviour when applying AI analysis during the control process, and we adopt DoC theories to draw insights into project managers' behaviour. Pan and Pan (2011) suggest that de-escalation can be considered more significant to understand than EoC since de-escalation remedies the adverse effects of escalation. Escalation behaviour is explained through several complementary theories, for example, approach-avoidance theory (Keil et al., 2000, Mann, 1996, Pan and Pan, 2011, Pan et al., 2008), agency theory (Keil et al., 2000, Wang et al., 2020b), and prospect theory (Kahneman and Tversky, 1979, Tversky and Kahneman, 1974, Tversky and Kahneman, 2023, Wang et al., 2017).

This research aims to answer the following research question: *How do behavioural theories or constructs affect project managers during the project control process when using Artificial Intelligence technology as early warning sign tools?*

We aim to answer this question through qualitative data collection from 22 individual research participants with experience in using AI analysis for project control. We demonstrate our findings through a Causal Loop Diagram (CLD). Our research contributes to the literature on project escalation by highlighting a bias we call "Override AI". This bias affects managers' behaviour towards AI analysis during project control by overriding the AI analysis. We present our findings through feedback loops with the key variables "Perception of Project Uniqueness," "Non-sufficient AI Explainability," and "Information Asymmetry". Further, we suggest that the overriding AI bias negatively influences "Trust in AI Model".

The literature chapter introduces project success during control and demonstrates literature on DoC. Followed by expanding on specific project control phases, namely 1) setting up performance metrics, 2) comparing actual project performance with a set baseline, and 3) taking corrective actions (Olawale and Sun, 2013). In the first phase, we present literature on biased behaviour observed during project escalation. Additionally, we establish the literature on project performance and evaluation criteria. In the second phase, we review the literature on AI-based analytical tools for decision support. In the third phase, we focus on corrective actions and project managers' trust in AI.

6.2 Literature Review

6.2.1 Project Success Through Project Control

Project escalation occurs when the project can continue regardless of whether the success and performance are outside the set project objectives. Project success is an established research area (Padalkar and Gopinath, 2016). However, there is no standard terminology or best practice for evaluating projects (Meredith and Zwikael, 2019, Shenhar et al., 2001). “The iron triangle” with time, cost, and scope traditionally comprises the traditional metrics for evaluating project performance (Pollack et al., 2018, Todorović et al., 2015). Achieving project success is closely interrelated with setting and measuring correct project performance criteria, and researchers have demonstrated different assessment methods and frameworks to improve the project assessment process (Korhonen et al., 2023). It is suggested that when project stakeholders assess success they focus on effectiveness, whereas when they assess failure they focus on efficiency (Chipulu et al., 2019).

A significant challenge for projects within a portfolio organisation is the interdependencies between, for example, resources, technology, and market changes. Successful operations in these factors are suggested as necessary to achieve project success (Bathallath et al., 2016), as well as high project performance. It is significant to distinguish between “project management success” and “project success”. The former refers to the project manager’s responsibility to deliver the project outputs within time, cost, and quality. Whereas project success relates to the project owner and medium- to long-term project outcomes and impacts (Badewi, 2016, Chih and Zwikael, 2015, Terlizzi et al., 2016). Further on, what is perceived as a success depends on; “who is making” the evaluation, “when the evaluation” is being made, “what criteria” the review is based on, what “type of project” it concerns, as well as “which context” the project operates in (Pinto et al., 2022). Mahaney and Lederer (2010) propose that diligent monitoring only guarantees project success if the effort targets the correct priorities and tasks. To measure IT projects' performance, it is suggested to use eight evaluation steps during the structuring, evaluation, and recommendation phases (Lacerda et al., 2011). For this research, we adopt the three phases within project control suggested by Olawale and Sun (2013); 1) setting performance standards, 2) comparing actual performance with project baseline standards, and 3) taking necessary corrective actions. DoC is initiated after completing an analysis in the second phase, and the mitigation action is enforced in the third phase.

6.2.2 Setting Performance Standards

The first control phase is setting the performance standards (Olawale and Sun, 2013). The performance criteria are selected according to the project context and objectives, and it is significant to link the chosen criteria with the organisational success (Korhonen et al., 2023). Research suggests there is a clear correlation between projects applying project management success frameworks and project success (Mir and Pinnington, 2014). Some researchers suggest setting performance standards is part of the project initiation phase (Rolstadås et al., 2014). However, we include setting performance standards in the control phase (Olawale and Sun, 2013).

Early research in project performance is associated with "the conflict model", where conflict resolution correlates with project success (Robey et al., 1993), as well as "strategic", "informational", and "transactional benefits" to achieve success (Mirani and Lederer, 1998). Further on, projects have seen performance standards based on "an outcome perspective" through "tasks", "psychological", and "organisational outcome" (Aladwani, 2002). Setting the performance based on "scope" is suggested to be most significant for IT projects relative to the other iron triangle elements "time" and "cost" (Agarwal and Rathod, 2006). Gemino et al. (2007) expand this to include "mitigating project risks" as a critical success factor, whereas Mastrogiacomo et al. (2014) propose using a guide for communication to improve projects' coordination. Studies show that control practices differ depending on whether the project is internal or external to the delivery organisation (Tiwana and Keil, 2009). Sanchez et al. (2017) suggest beginning with setting an agreed scope while referring to "cost" and "time" as dependent on the factors "project size", "duration", "postponement", and the manager's "formal decision mandate". Setting up measuring standards to include people-centred aspects is specifically significant for agile projects and includes the level of customer involvement (Tam et al., 2020). Pereira et al. (2022) demonstrate that the criteria in the iron triangle are commonly used among project managers, where client satisfaction was only included as a criterion in half of the studied projects. Alarmingly, the researchers conclude that projects rarely include a defined performance standard or evaluation process.

6.2.3 Comparing Actual Performance with Project Baseline

The second control phase is comparing the performance with the set standards (Olawale and Sun, 2013). Comparing the actual project performance with the set project plan is an essential control activity (Acebes et al., 2015, Vanhoucke, 2012a). This activity is aggregated from reporting the progress and analysing the performance (Olawale and Sun, 2013, Olawale and Sun, 2015). Monte Carlo is a well-established tool for risk management during project control

(Kwak and Ingall, 2007, Vanhoucke, 2013). The method uses multiple simulations to reproduce the project outcome (Kwak and Ingall, 2007). Additionally, Earned Value Management (EVM) is a widely studied method for project control and typically includes the parameters earned value, planned value, and actual cost (Acebes et al., 2014, Hazır, 2015, Pellerin and Perrier, 2019, Rozenes et al., 2006, Song et al., 2020). Several researchers suggest that AI technology has significant potential to improve current decision support systems, including project management systems (Gupta et al., 2021, Duan et al., 2019, Dwivedi et al., 2021, Haenlein and Kaplan, 2019, Hajiali et al., 2020, Loureiro et al., 2021, Ormerod, 2020a, Pomerol, 1997, Rosenthal-Sabroux and Zaraté, 1997). In our research context, the project manager applies an AI model as an analytical tool to act as an early warning system. During the controlling phase, the AI model analyses the project performance and indicates when the project requires mitigation action (Pellerin and Perrier, 2019).

Applying advanced AI models based on machine learning brings challenges in the sense of interpreting the AI output and is referred to “AI-black box” (Saranya and Subhashini, 2023, Hoffman et al., 2018, Hassija et al., 2024, Arrieta et al., 2020). As a solution, the literature suggests implementing explainable AI models (Gunning and Aha, 2019, Hoffman et al., 2018, Miller, 2019, Shin and Park, 2019). Explainable AI models aim to increase “transparency”, “trustworthiness”, and “accountability” (Saranya and Subhashini, 2023). Whereas Ali et al. (2023) propose four factors to increase a model’s “trustworthiness” and “robustness”, namely “data explainability”, “model explainability”, “post-hoc explainability”, and “assessment of explanations”. On the other hand De Bock et al. (2024) suggest focusing on “AI performance”, “attributable”, and “responsible analytics”.

Researchers find AI models to be successfully applied for performance analysis for cost and cash flow (Cheng et al., 2020, Cheng et al., 2015, Cheng and Roy, 2011, Cheng et al., 2009c), as well as control activities of scheduling and quality control (Garcia et al., 2017). Martínez and Fernández-Rodríguez (2015) reviewed the literature on success factors and AI. They found specific AI algorithms suitable for determining the set success factors and analysing the project performance. Additionally, the potential of AI to be a success factor in itself is studied in the project construction industry (Kumar et al., 2021). Further, researchers find combining project control tools, such as Earned Value Management (EVM), with AI modelling efficient to increase the analytical capability of the project analysis (Hajiali et al., 2020, Wauters and Vanhoucke, 2016, Wauters and Vanhoucke, 2017, Willems and Vanhoucke, 2015). However, a challenge for project organisations in applying AI analysis is that the required AI training data is unavailable due to the lack project data processes.

Setting aside technical challenges for the AI analysis, the reporting and analytical activities in the controlling phase involve critical engagement from the project manager. However, challenges are found in the decision-making process, suggesting biased behaviour influences managers' decisions (Flyvbjerg et al., 2022, Kaufmann and Kock, 2023, Keil et al., 2000, Keil and Robey, 2001, Wang et al., 2020a, Kahneman and Tversky, 2013, Tversky and Kahneman, 1974, Tversky and Kahneman, 2023, Simon et al., 1987). Flyvbjerg (2021) suggests that "uniqueness bias" is significant for project managers as they believe their project is unique to the point where they have little in common with other projects, resulting in bias analysis. To prevent biases, project managers can benefit from "comparative overrun", this method is inspired by the assessment method of "reference class forecasting", however, it differentiates by not forecasting future outcomes and does not require a vast amount of data (Delise et al., 2023).

6.2.3.1 Trust in AI

To justify one's decision, an AI model is recommended to include a sufficient level of "transparency", "traceability" and "explainability" (Dwivedi et al., 2021). Researchers have studied the application of AI agents as team members, where high-performing AI systems are likely to be accepted as part of a team (Dennis et al., 2023). As well as collaboration between advanced AI models and human intervention is shown to be effective during long-term predictions while less effective for short-term estimates (Revilla et al., 2023). Glikson and Woolley (2020) suggest "transparency", "tangibility", and "immediacy behaviour and reliability" are factors significant for building trust in AI. They continue proposing categorising trust through "cognitive" and "emotional" trust. This was expanded by Gkinko and Elbanna (2023) who added "organisational" trust to the list.

Users' trust can be divided into "initial trust" and "trust over time". The former is shaped by the individual's "propensity" to trust, whereas the latter is affected by "social influence", "familiarity", and "system-like characteristics" of AI algorithms. Additionally, human-like aspects of the AI system, such as anthropomorphism, affect users' trust (Cabiddu et al., 2022). Beyond the mentioned factors, aligning the goals and values of the decision-maker and the AI system is suggested to increase trust (Saffarizadeh et al., 2024).

6.2.4 Corrective Action Through De-Escalation of Commitment

The third phase is taking necessary corrective actions (Olawale and Sun, 2013). In our research context, the manager decides whether or not to take mitigation action or continue the project based on the AI control analysis. The concept of DoC has not received the same attention compared with EoC and related theories within project escalation (Pala et al., 2015, Pan et al., 2006). EoC is a common biased behaviour of project managers, often explained as when

managers throw good money after bad investments, allowing projects to continue regardless of poor performance (Martens and Orzen, 2021, Juarez Cornelio et al., 2021, Drummond, 2014, Keil et al., 2007, Berente et al., 2022, Flyvbjerg et al., 2022). On the other hand, DoC is defined as taking mitigation action leading to redirection or termination of the project (Montealegre and Keil, 2000). Keil and Robey (1999, p.65) explain DoC through the following quotation:

"... the reversal of escalating commitments to a failing course of action, either through project termination or redirection."

Feldman and Wong (2018) discuss the critical aspect of defining "action" within project escalation:

"... escalation situations are often described in ambiguous terms with respect to whether they involve action or inaction. Does choosing to proceed [with the current investment] constitute action or inaction? How about choosing to withdraw?" (p.538).

The authors suggest that action and inaction have different meanings depending on the formulated question. Traditionally, an "action" can be seen as part of the EoC concept, as decision-makers spend more money, resources, and efforts on failing projects (Kahneman and Tversky, 1979, Sleesman et al., 2018, Staw, 1997). Whereas Feldman and Wong (2018) suggest framing "action" as de-escalation and "inaction" as escalation to decrease the tendency for EoC.

Staw and Ross's (1987) work identifies four determinants that explain the causes of EoC, and this is clarified by Sleesman et al. (2012): 1) "Project determinants" are based on the decision-maker's evaluation of either escalating or de-escalating the project through the expected utility. 2) "Psychological determinants" are supported by theories such as "prospect theory", and "approach-avoidance theory". Projects can benefit from Pan et al. (2006) who suggest using an evaluation process based on approach-avoidance. 3) "Social determinants" are based on managers' social setting and desire to avoid admitting that escalation cannot be justified. Subsequently admitting that previous investments are unjustified. 4) The fourth determinant is "structural", where the overall project objective becomes misaligned with the project manager. This can be explained through "agency theory", where the manager's incentive drives the escalation (Sleesman et al., 2012). The misalignment of goals is based on the "agent" and the "principal", where the former serves as a decision-maker on behalf of the latter. This phenomenon can be explained through "information asymmetry" (Jensen and Meckling, 1976; Keil et al., 2000).

6.2.4.1 Techniques to Improve De-escalation

Staw (1981) suggests reducing EoC by providing "an outside view" to a project by including external individuals with an unbiased outside view. This is supported by Haji-Kazemi et al. (2015) who propose that individuals with an outside view are more likely to acknowledge early warning signs of escalation. Further on, research suggests that individuals with an outside perspective can be more objective and mitigate biased behaviour (Flyvbjerg, 2013). The opposite, an "inside view" explains when managers focus on details in a specific situation and ignore previous experiences (Kahneman and Lovallo, 1993). In this sense, the individual is limited in their rationality and ability to learn from their mistakes (Tiwana et al., 2007, Gigerenzer, 2004, Katsikopoulos, 2014, Simon, 1972). Natarajan (2022) proposes applying AI for project data analysis as an effective way to apply an outside view. In this case, the AI provides an external perspective. By adopting an "outside view", the project manager looks at the bigger picture, ignores small details, and compares the situation with other cases through the concept reference classes. Summarised, the inside view is seen as a "bottom-up" approach, whereas the outside view is a "top-down" perspective (Kahneman et al., 2011, Lovallo and Kahneman, 2003).

IT projects can specifically benefit from the following six de-escalation techniques "agile mobilising" (before mitigation), "provision of psychological safety" (before mitigation), "consultation" (before mitigation), "personal appeal" (during mitigation), "re-establish legitimacy and stakeholder commitment" (after mitigation), and "continuous empowerment" (after mitigation) (Pan and Pan, 2011). Lee et al. (2021) propose avoiding "a growth mindset" to increase DoC. A growth mindset is often seen as a positive characteristic for managers, leading to a high ambition to learn and develop. However, it may also cause EoC when the manager lacks a critical view of the evaluation process. For new product development IT projects, Yang et al. (2023) suggest using "open innovation" to distribute responsibility and knowledge among as many stakeholders as possible. Further on, team members of a product team experienced less EoC when they adopted the perspective of other stakeholders, known as "perspective-taking" (Lee et al., 2018). Lee et al. (2012) demonstrate that setting specific schedules and budget goals provides a distinct decision-making reference point and may reduce EoC.

To justify the actions of DoC or EoC, Sleesman (2019) suggests using a strict protocol with alternative solutions and the expected consequence of the proposed corrective action. However, the traditional view is that de-escalation requires a higher level of justification because it is seen as a more radical action than EoC. Drummond (1995) argues that both DoC and EoC require the same level of justification from the decision-maker. Berente et al. (2022) take an institutional perspective and suggest projects can continue due to institutional logic and

institutionally legitimised in organisations, meaning DoC requires institutional de-escalation efforts. Other researchers suggest that fundamental project control and reporting processes reduce EoC behaviour (Chong and Suryawati, 2010).

Project managers' attitudes towards escalation differ depending on the project life cycle. Positive feedback on project performance early in the life cycle tends to reinforce EoC behaviour (Noda and Bower, 1996, Sleesman et al., 2018), whereas early negative feedback tends to favour DoC (Drummond, 1995). He and Mittal (2007) suggest managers are most prone to EoC during the project execution stage, which is similar to Wang et al. (2020b) who demonstrate that EoC is commonly studied within the control phase of the project life cycle.

The concept of "the feeling of regret" was utilised by Ku (2008) to understand if individuals can learn from previous mistakes. The participants were asked to remember previous EoC experiences before an escalating situation occurred. The participants demonstrated a significantly reduced escalation tendency. This suggests that a source of DoC can be found within individuals' specific experiences and requires actively recalling previous escalating situations (Chong and Suryawati, 2010, Ku, 2008). Additionally, the modelling technique CLD is suggested to reduce EoC through visualising the cause-and-effect of decisions and demonstrating feedback loops of the escalating situation. The method provides root cause explanations and can identify alternatives for corrective action (Pala et al., 2015). See Figure 14 for a CLD model demonstrating the feedback loops of EoC and DoC based on the premise of managers receiving a warning sign from an AI control system indicating that the project is escalating. Loop 1 demonstrates how EoC increases project escalation which in turn increases EoC behaviour. Loop 2 demonstrates the causal link from project escalation triggers the AI warning sign which increases DoC and triggers a corrective action. This decreases the project escalation and creates a balancing EoC loop representing DoC behaviour. We adopt the CLD modelling technique to visualise our research findings.

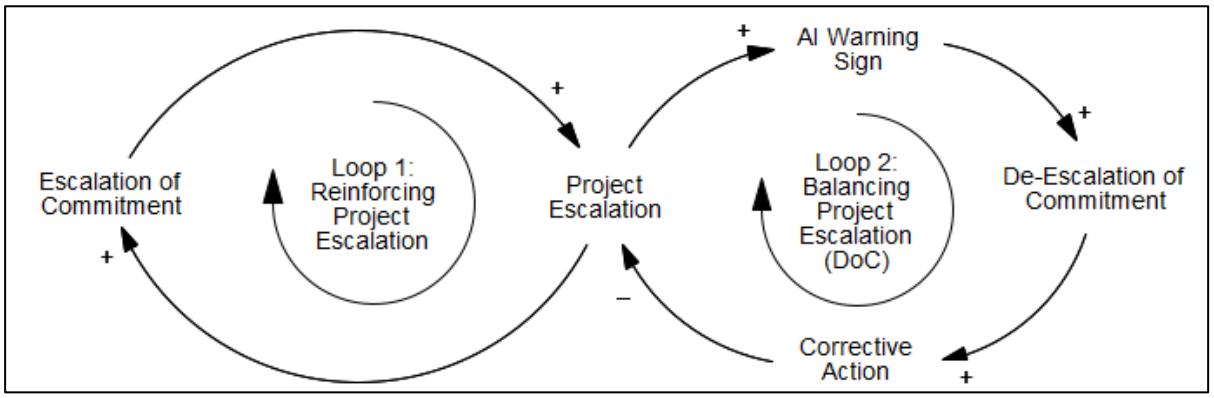

Figure 14: Reinforcing and Balancing loops of Project Escalation

6.3 Research Method

We adopted the research method and strategy Grounded Theory, which allowed us to explore themes as they emerged during the data collection which is based on interviews with 22 research participants (Glaser and Strauss, 1967). This method is based on iterative coding phases and data collection. To demonstrate the research findings, we adopted the modelling technique CLD. The technique is an established approach when studying project managers' decision-making behaviour (Hämäläinen et al., 2013, Wang et al., 2020b, Abdel-Hamid, 2011, Cooper, 1993b, Ford and Lyneis, 2020, Ford et al., 2007, Ford and Sterman, 2003, Lyneis and Ford, 2007, Son and Rojas, 2011, Wang et al., 2017).

The combination of Grounded Theory and CLD is well suited, and both methods allow to conduct qualitative research based on interviews (Kopainsky and Luna-Reyes, 2008, Luna-Reyes and Andersen, 2003, Tomoaia-Cotisel et al., 2022). Additionally, the methods suggest using an iterative process and analysing data through specific coding stages (Yearworth and White, 2013).

CLD modelling is based on either "regular variables", which are influenced by casual effects, or "constant variables" (Sterman, 2000). We follow the following four CLD modelling steps: 1) identifying the variables in the data through first-order open coding, 2) understanding the direction of causality through second-order axial coding, 3) assigning polarities of positive or negative relationships on the causalities through second-order coding, and 4) connecting variables to form feedback processes and determining the feedback as reinforcing or balancing through third-order selective coding (Kunc, 2017b, Sterman, 2000). The feedback loops comprise the most significant variables and represent the research phenomenon.

To complement our findings, we apply the causal links of the "project rework", which is a recognised concept in project research (Cooper, 1993a, Ford and Lyneis, 2020, Jalili and Ford, 2016, Khatun et al., 2023, Love et al., 2002, Love et al., 2023, Lyneis and Ford, 2007, Rahmandad and Hu, 2010).

6.3.1 Data Analysis

We collected interview data from 22 project managers through semi-structured interviews. The selection process of the participants involved setting the criteria of only including project managers with experience in using decision support systems based on AI control analysis. The interviews were held with managers from the IT, construction, aviation, and automotive industries, and the findings represent a cross-industry project environment. Including a diverse range of industries benefits the research findings, allowing us to generalise our findings and

extend the research implications to the project management community. The data was collected through digital qualitative interviews through Microsoft Teams during the period of January 2020 to May 2022.

Grounded Theory is a systematic strategy using an iterative approach to analyse data and develop a theory (Saunders et al., 2009). It was formulated by Glaser and Strauss (1967) (Charmaz, 2006, Locke, 2000, Saunders et al., 2009), and according to Glaser and Strauss (1967) it offers a way to systematically analyse and interpret qualitative data to develop a theory. At the same time, CLD provides a visual and holistic representation of the studied phenomena, and the novel field of AI and project management benefits from an inductive approach supported by both methods (Yearworth and White, 2013, Mingers and White, 2010). In this sense, Grounded Theory and CLD are suitable to combine, as they overlap in the analysis process while complementing each other through clear coding steps and visually demonstrating the findings (Kopainsky and Luna-Reyes, 2008, Luna-Reyes and Andersen, 2003). The iterative processes help validate the findings and capture the complex environment of AI in projects. Further, the feedback loops provide a holistic understanding of the studied managers' decision-making process, which enhances the understanding of the novel research area of AI and project managers.

The data analysis followed the coding phases of Grounded Theory: 1) Open coding, where the interview data is coded into categories, or variables; 2) axial coding, where relationships between the variables are identified; and 3) selective coding, where the identified relationships between the variables are explained. See Table 17 for data analysis and coding of the interview data for the CLD.

Table 17: Coding process for override AI causal loop diagram

First Order: Open Coding **Based on interview data and literature.**	**Second Order: Axial Coding** **Identified CLD variables from interview data.**	**Third Order: Selective Coding** **Feedback loop and casual links.**
Reinforcing Loop 1: Override AI Bias		
		Feedback loop: Override AI Bias (positive) → Rework Discovery (positive) → Project Reporting (positive) → Project Rework (positive) → Project Overruns (positive) → Misaligned Goals and Objectives (positive) → Override AI Bias
"When I decide to go for plan B, even if the AI is not suggesting so [override AI bias], I then mark some areas red [rework discovery]." Participant 6	Variables: "Override AI Bias" "Rework Discovery"	R1 Override AI Bias causal link: Override AI Bias (positive) → Rework Discovery

First Order: Open Coding **Based on interview data and literature.**	**Second Order: Axial Coding** **Identified CLD variables from interview data.**	**Third Order: Selective Coding** **Feedback loop and casual links.**
"I mean it would be better if the team, myself and the AI all come with the same conclusion, but this scenario [information asymmetry / when AI and PM is not aligned] is not always bad since it provides alternative perspectives and identify delays [rework discovery], which I think in the end is positive as long as the disagreements are rational [override AI bias]." Participant 20		
Override AI bias is explained as the project manager takes corrective action which by definition discovers rework.		
The variable "Rework Discovery" is a pre-requisite to perform the variable "Project reporting" activity, which in turn is necessary to identify "Project Rework". This leads to an increase of "Project Work to Do".	Variables: "Rework Discovery" "Project Reporting" "Project Rework"	R1 Override AI Bias causal links: Rework Discovery (positive) → Project Reporting (positive) → Project Rework (positive) → Project Work to Do
"When we identify tasks that we need to redo [project rework], it will obviously be a risk that we don't keep our deadlines and schedule [project overruns]." Participant 11	Variables: "Project Rework" "Project Overruns"	R1 Override AI Bias causal links: Project Rework (positive) → Project Work to Do (positive) → Project Overruns
"We do have issues with feeding and training the AI with the newest information such as the latest interruption [project overruns], leading to the analysis is not always up to date [misaligned goals and objectives]." Participant 18	Variables: "Project Overruns" "Misaligned Goals and Objectives"	R1 Override AI Bias causal links: Project Overruns (positive) → Misaligned Goals and Objectives
"We wish we could report in a "live format" which would increase our reporting frequency. This would mean we would have more relevant information. Now we have to settle with reporting as project goes on and as close to "live" as possible…. Unfortunately this leads to the AI is not always fed with the newest data and delays [project overruns], and it affects its output [misaligned goals and objectives]." Participant 3		
"I feel that the AI is very often on point with its analysis, but I do also feel that I sometimes have the most relevant information based on a recent delay [project overruns] [misaligned goals and objectives]…" Participant 20		
"I feel that the AI is very often on point with its analysis, but I do also feel that I sometimes have the most relevant information based on a recent delay [misaligned goals and objectives] and can therefore take the decision to override the AI suggestion [override AI bias]." Participant 20	Variables: "Misaligned Goals and Objectives" "Override AI Bias"	R1 Override AI Bias causal links: Misaligned Goals and Objectives (positive) → Override AI Bias
"When the project is in need of a fast decision, we don't have time to wait and update the data, we do need to improve our data management and processing but that's another question, anyway we don't have time to update the AI and it means the team and I sit on the most accurate information to make an informed decision [misaligned goals and objectives]. Leading to we do something else than what the AI suggests [override AI bias]." Participant 18		
"Sometimes the AI and myself have different conclusion [override AI bias], and the reason for this is we have different sets of skills, but also we have different information [misaligned goals and objectives]." Participant 20		

First Order: Open Coding **Based on interview data and literature.**	**Second Order: Axial Coding** **Identified CLD variables from interview data.**	**Third Order: Selective Coding** **Feedback loop and casual links.**
"If the AI has different data then the information given to me , which happens sometimes [misaligned goals and objectives], then if I find that something is not right I will sometimes not follow that AI output [override AI bias]." Participant 6		
"It is unfortunately not possible for us to feed the AI with live data, so we have different perspectives to say it nicely sometimes [misaligned goals and objectives]... So its not always relevant to listen to the AI [override AI bias]. Participant 11		
Reinforcing Loop 2: Escalation of Commitment		
		Feedback loop: Escalation of Commitment (negative) → Project Rework (positive) → Project Overruns (positive) → Misaligned Goals and Objectives (positive) → Override AI Bias (negative) → Trust in AI Model (positive) → Escalation of Commitment
The behavioural construct of "Escalation of Commitment" continues project escalation and by default decreases project rework. (Berente et al., 2022, Brockner, 1992, Staw, 1997, Staw and Ross, 1987)	Variables: "Escalation of Commitment" "Project Rework"	Causal links: Escalation of Commitment (negative) → Project Rework
"When we identify tasks that we need to redo [project rework], it will obviously be a risk that we don't keep our deadlines and schedule [project overruns]." Participant 11	Variables: "Project Rework" "Project Overruns"	R2 Escalation of Commitment causal links: Project Rework (positive) → Project Overruns
"We do have issues with feeding and training the AI with the newest information such as the latest interruption [project overruns], leading to the analysis is not always up to date [misaligned goals and objectives]." Participant 18	Variables: "Project Overruns" "Misaligned Goals and Objectives"	R2 Escalation of Commitment causal links: Project Overruns (positive) → Misaligned Goals and Objectives
"We wish we could report in a "live format" which would increase our reporting frequency. This would mean we would have more relevant information. Now we have to settle with reporting as project goes on and as close to "live" as possible.... Unfortunately this leads to the AI is not always fed with the newest data and delays [project overruns], and it affects its output [misaligned goals and objectives]." Participant 3		
"I feel that the AI is very often on point with its analysis, but I do also feel that I sometimes have the most relevant information based on a recent delay [project overruns] [misaligned goals and objectives]..." Participant 20		
"I feel that the AI is very often on point with its analysis, but I do also feel that I sometimes have the most relevant information based on a recent delay [misaligned goals and objectives] and can therefore take the decision to override the AI suggestion [override AI bias]." Participant 20	Variables: "Misaligned Goals and Objectives" "Override AI Bias"	R2 Escalation of Commitment causal links: Misaligned Goals and Objectives (positive) → Override AI Bias
"When the project is in need of a fast decision, we don't have time to wait and update the data, we do need to improve our data management and processing but that's another question, anyway we don't have time to update the AI and it means the		

First Order: Open Coding **Based on interview data and literature.**	**Second Order: Axial Coding** **Identified CLD variables from interview data.**	**Third Order: Selective Coding** **Feedback loop and casual links.**
team and I sit on the most accurate information to make an informed decision [misaligned goals and objectives]. Leading to we do something else than what the AI suggests [override AI bias].” Participant 18		
“Sometimes the AI and myself have different conclusion [override AI bias], and the reason for this is we have different sets of skills, but also we have different information [misaligned goals and objectives].” Participant 20		
“If the AI has different data then the information given to me, which happens sometimes [misaligned goals and objectives], then if I find that something is not right I will sometimes not follow that AI output [override AI bias].” Participant 6		
“It is unfortunately not possible for us to feed the AI with live data, so we have different perspectives to say it nicely sometimes [misaligned goals and objectives]… So its not always relevant to listen to the AI [override AI bias].” Participant 11		
“Sometimes the AI and myself have different conclusion [override AI bias], and the reason for this is we have different sets of skills, but also we have different information. You can then understand I have little to no confidence in the AI output [trust in AI model].” Participant 20	Variables: “Override AI Bias” “Trust in AI Model”	R2 Escalation of Commitment causal links: Override AI Bias (negative) → Trust in AI Model
“If the AI has different data then the information given to me, which happens sometimes, then if I find that something is not right I will sometimes not follow that AI output [override AI bias]. Since I also probably don’t trust the AI in this case [trust in AI model].” Participant 6		
“It is unfortunately not possible for us to feed the AI with live data, so we have different perspectives to say it nicely sometimes…So its not always relevant to listen to the AI [override AI bias].... It results in a low trust in the AI [trust in AI model].” Participant 11		
The premise of the research is that the AI analysis is not indicating mitigation action is needed, i.e. the AI suggests to continue the project escalation. Trust in the AI analysis [trust in AI model] increases Escalation of Commitment behaviour.	Variables: “Trust in AI Model” “Escalation of Commitment”	R2 Escalation of Commitment causal links: Trust in AI Model (positive) → Escalation of Commitment
Constant variables		
“Sometimes the AI and myself have different conclusion, and the reason for this is we have different sets of skills, but also we have different information [information asymmetry]. You can then understand I have little to no confidence in the AI output [trust in AI model].” Participant 20	Constant variable: “Information Asymmetry” Variable: “Trust in AI Model”	Causal link: Information Asymmetry (negative) → Trust in AI Model
“If the AI has different data then the information given to me, which happens sometimes [information asymmetry], then if I find that something is not right I will sometimes not follow that AI output. Since I also probably don’t trust the AI in this case [trust in AI model].” Participant 6		
“It is unfortunately not possible for us to feed the AI with live data, so we have different perspectives to say it nicely sometimes [information asymmetry].. So its		

First Order: Open Coding **Based on interview data and literature.**	**Second Order: Axial Coding** **Identified CLD variables from interview data.**	**Third Order: Selective Coding** **Feedback loop and casual links.**
not always relevant to listen to the AI… It results in a low trust in the AI [trust in AI model].” Participant 11		
“I feel that the AI is very often on point with its analysis, but I do also feel that I sometimes have the most relevant information based on a recent delay [information asymmetry] and can therefore take the decision to override the AI suggestion… Because I don’t have trustworthy AI output [trust in AI model].” Participant 20		
“When the project is in need of a fast decision, we don’t have time to wait and update the data, we do need to improve our data management and processing but that’s another question, anyway we don’t have time to update the AI and it means the team and I sit on the most accurate information to make an informed decision [information asymmetry]. Leading to we do something else than what the AI suggests… I cannot follow an AI that I don’t trust have the correct information [trust in AI model].” Participant 18		
"We wish we could report in a "live format" which would increase our reporting frequency. This would mean we would have more relevant information. Now we have to settle with reporting as project goes on and as close to “live” as possible…. Unfortunately this leads to the AI is not always fed with the newest data and delays [project overruns], and it affects its output [misaligned goals and objectives]." Participant 3	Constant variable: “Information Asymmetry” Variable: “Misaligned Goals and Objectives”	Causal link: Information Asymmetry (positive) → Misaligned Goals and Objectives
“I feel that the AI is very often on point with its analysis, but I do also feel that I sometimes have the most relevant information [information asymmetry] based on a recent delay [misaligned goals and objectives]…” Participant 20		
“When the project is in need of a fast decision, we don’t have time to wait and update the data, we do need to improve our data management and processing but that’s another question, anyway we don’t have time to update the AI and it means the team and I sit on the most accurate information [information asymmetry] to make an informed decision [misaligned goals and objectives].” Participant 18		
“Sometimes the AI and myself have different conclusion, and the reason for this is we have different sets of skills, but also we have different information [information asymmetry] [misaligned goals and objectives].” Participant 20		
“If the AI has different data then the information given to me [information asymmetry], which happens sometimes [misaligned goals and objectives], then if I find that something is not right I will sometimes not follow that AI output [override AI bias].” Participant 6		
“It is unfortunately not possible for us to feed the AI with live data, so we have different perspectives to say it nicely sometimes [information asymmetry] [misaligned goals and objectives]… So its not always relevant to listen to the AI. Myself and the team are essentially not aligned with the AI [information asymmetry].” Participant 11		

First Order: Open Coding **Based on interview data and literature.**	**Second Order: Axial Coding** **Identified CLD variables from interview data.**	**Third Order: Selective Coding** **Feedback loop and casual links.**
"I sometimes ask another project manager or colleague for a second opinion, I do this mainly to get their input and perspective. But also myself, if I have more experience [personal experience] then rest of the team, I will be able to bring another perspective [outside view] and identify when things go wrong faster [rework discovery]." Participant 20	Constant variable: "Project Manager's Experience" Variable: "Outside view" "Rework Discovery"	Causal link: Project Manager's Experience (positive) → Outside view (positive) → Rework Discovery
"I want the best project manager with the best relevant knowledge of what we are going to do [project experience], then I know we will best chances to find issues quickly, call it a different way to see things [outside view] [rework discovery], and fix them." Participant 6		
Outside view is a technique for de-escalating projects and to avoid escalation, i.e. explained through "Override AI Bias" loop, which is a rework discovery activity. This is supported through the literature (Kahneman and Lovallo, 1993, Kahneman et al., 2011, Lovallo and Kahneman, 2003).		
"I tend to see myself and others have a tendency to believe the project we are working on is special, it's our little baby [perception of project uniqueness], and is sometimes used as an argument not to trust the AI performance. Essentially it leads to the team and I not following the AI analysis. [override AI bias]." Participant 4	Constant variable: "Perception of Project Uniqueness" Variable: "Override AI Bias"	Causal link: Perception of Project Uniqueness (positive) → Override AI Bias
"There are some unique areas in every project, sometimes the team and I overestimate the value of these unique traits [perception of project uniqueness], sometimes we don't, but when we do it affects how we interact with the AI and if we can be sure its fed with relevant data so we can trust it… I then may choose to follow the team's analysis if it is not aligned with the AI [override AI bias]." Participant 11		
"We have learnt that all projects are unique, and its true to some extent, this perception makes me question what data is fed to the model and if the model's output is useful or not." Participant 12		
"It's the same with trust issues, if I cannot understand the AI output [non-sufficient AI explainability], I am more likely to go against the AI [override AI bias] if I believe we have better analysis and information somewhere else." Participant 20	Constant variable: "Non-Sufficient AI Explainability" Variable: "Override AI Bias"	Causal link: Non-Sufficient AI Explainability (positive) → Override AI Bias
"It's quite evident that if I the AI offers an explanation of good quality [non-sufficient AI explainability] I will be able to trust it is telling the truth… Which otherwise I will not hesitant to go with my instinct and go against the analysis [override AI bias]." Participant 12		
"The better the explanation is the more I can believe its output is correct [non-sufficient AI explainability]. If not, it will be difficult for the team and I to justify follow the AI [override AI bias]." Participant 11		

6.4 Results

We present the results through a CLD model, and our findings are illustrated through feedback loops where significant variables are included with cause-and-effect polarities. In our CLD model, the AI analysis does not indicate a warning sign of project escalation. However, the project manager identifies project rework and overrides the AI analysis based on behavioural biases. This leads to the behavioural construct of DoC we call “Override AI Bias”. The CLD model is made up of two reinforcing loops with complementary variables. Constant variables are modelled in capital letters, and each variable’s causal influence is demonstrated with a positive or negative sign.

6.4.1 Feedback Loop 1: Override AI Bias

The first loop in our model is a reinforcing loop named “Override AI Bias”, see Figure 15. This loop represents the decision to go against the AI recommendation to de-escalate the project and take corrective action. We found the variable “Override AI Bias” to be significant in our research and is affected positively by the two constants “Perception of Project Uniqueness”, and “Non-sufficient AI Explainability”. The bias increases the variable “Rework Discovery”, which is influenced positively by the variables “Project Manager’s Experience” and “Outside View”, where the former is modelled as a constant. Further, “Rework Discovery” increases “Project Reporting”, followed by “Project Rework”, which is influenced by the constant “Error Generation”. This constant represents the rate of errors causing rework, followed by “Project Rework” positively influencing “Project Work to Do”. Additionally, this variable is influenced by the constants “Initial Work” and “Progress”. Initial work represents the initial project work when the project started, whereas the “Progress” variable decreases work to do. The completion of project work is modelled through “Project Work to Do”, negatively influencing “Project Completion”, which is also positively influenced by “Progress”. Demonstrating the process of completing project work is found in the project management literature through, for example the “Rework Cycle” by Ford and Lyneis (2020). For a profound demonstration of the rework cycle, we refer to the work of the mentioned authors. In our model, we have simplified the rework process and modelled the rework cycle as a causal loop. Further on, “Project Rework” increases “Project Overruns”, which in turn increases “Misaligned Goals and Objectives”. This variable is affected by the constant “Information Asymmetry” and increases “Override AI Bias”.

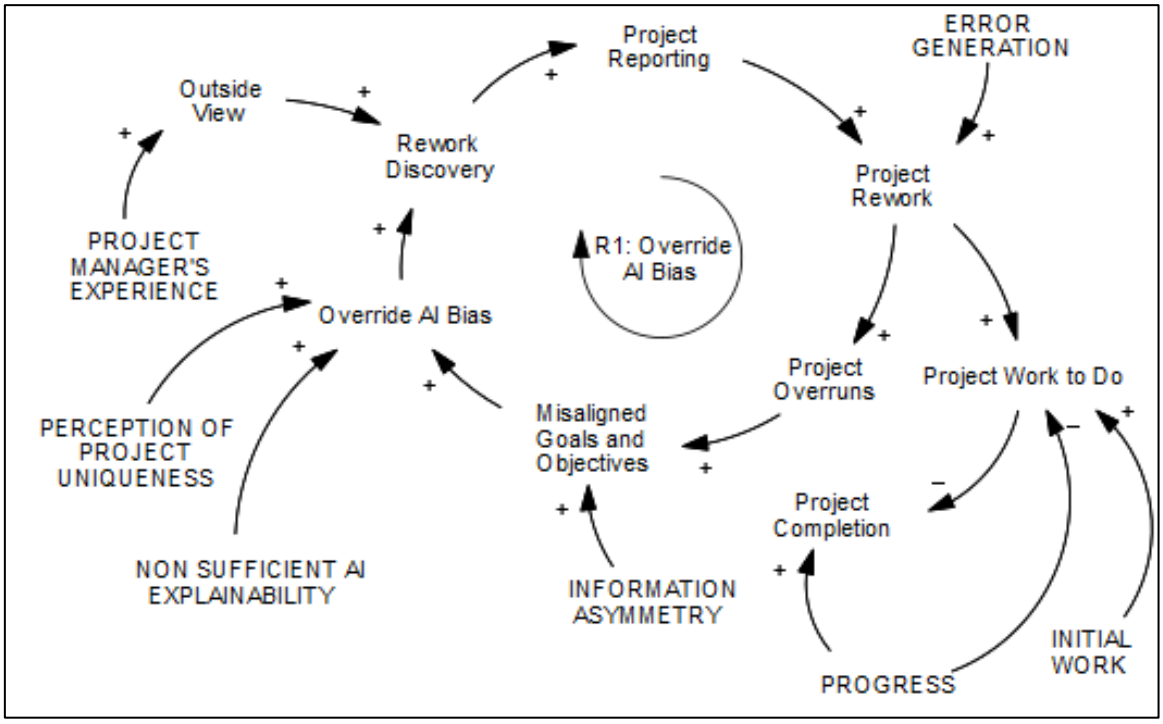

Figure 15: Reinforcing Loop 1: Override AI Bias

6.4.2 Feedback Loop 2: Escalation of Commitment

Adding the second loop, we find the complete CLD model presented in Figure 16, which represents a reinforcing loop of EoC. We found the constant “Information Asymmetry” to be significant and decreases “Trust in AI Model”. Additionally, “Override AI Bias” decreases trust in AI, which increases the variable “Escalation of Commitment”. Further, EoC decreases “Project Rework”, followed by the causal chain in the previously mentioned loop. Table 18 includes all the variables’ causal links and polarities.

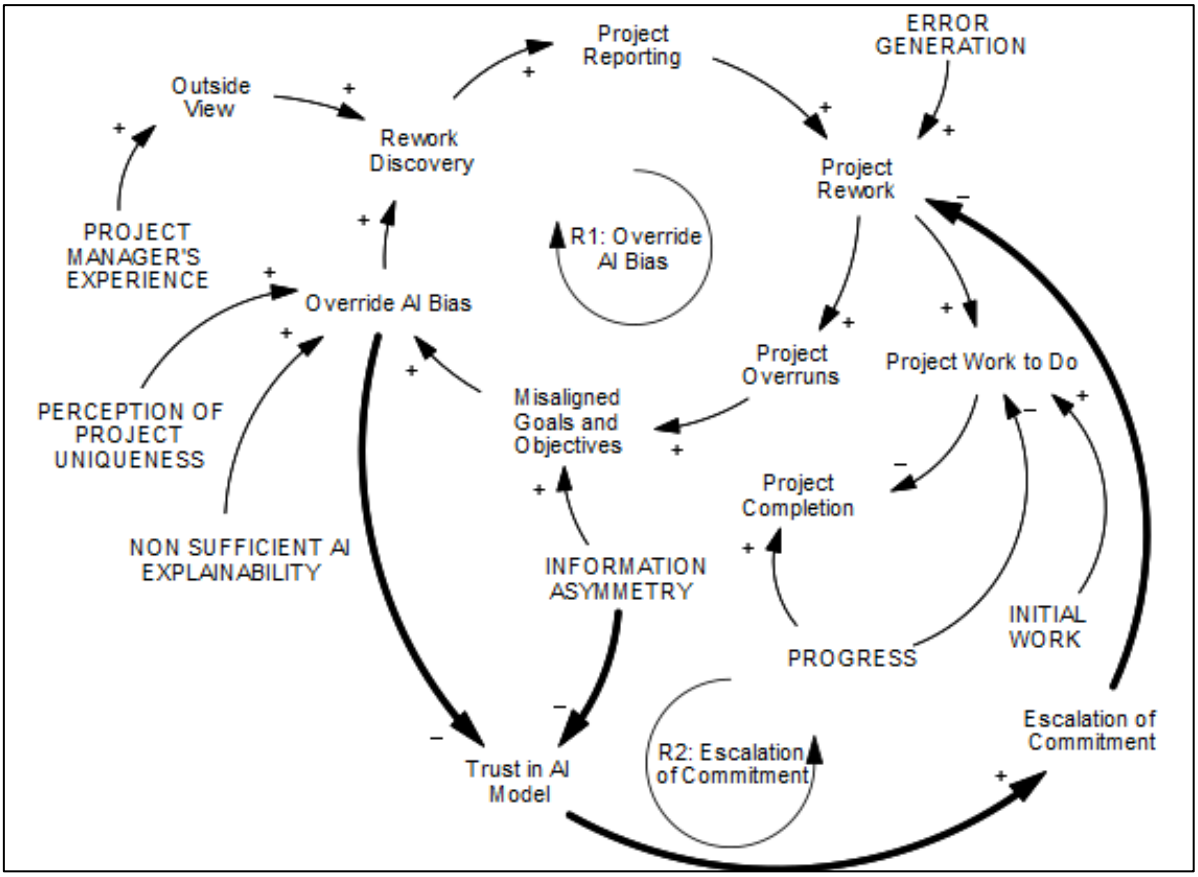

Figure 16: Reinforcing Loop 2: Escalation of Commitment

Table 18: Summary of all feedback loops of override AI bias CLD

Feedback loops	Characteristics (feedback strength and time delay)	Comment
R1: Override AI Bias → Rework Discovery → Project Reporting → Project Rework → Project Overruns → Misaligned Goals and Objectives	Strong feedback Long term time delay	Override AI Bias is a strong feedback which overrules the EoC behaviour. It is a long term delayed feedback loop due to it is a delayed response to the project escalation.
R2: Escalation of Commitment → Project Rework → Project Overruns → Misaligned Goals and Objectives → Override AI Bias → Trust in AI Model	Medium strength feedback Short term delay	Escalation of Commitment is a medium strength feedback since it is overruled by the loop "Override AI Bias". It is a short term delayed feedback due to it is active from the start of the model and it is managers' default behaviour until the project manager takes corrective action.

6.5 Discussion

Our paper studies the behaviour of project managers' decision-making when applying AI analysis for project control. Then we presented our findings through a CLD model. Through our discussion we will answer our research question: *How do behavioural theories or constructs affect project managers during the project control process when using Artificial Intelligence technology as early warning sign tools?* The discussion focuses on the main findings of the

feedback loop Override AI Bias with key influencing variables “AI Explainability”, “Perception of Project Uniqueness”, “Information Asymmetry”, and “Misaligned Goals and Objectives”, as well as the complementing “Outside View”. Additionally, we discuss the second loop, Escalation of Commitment, with the critical variable “Trust in AI Model”.

6.5.1 De-escalation of Commitment through Override AI

The reinforcing loop “Override AI Bias” is our main contribution where managers’ biased behaviour favours de-escalating projects during AI analysis. Our research suggests that this is a significant bias behaviour leading to de-escalation. We propose that this is a unique bias in the context of project managers’ decision-making augmented by AI analysis. Further, the bias is influenced by AI explainability, perception of project uniqueness, and information asymmetry, which leads to misaligned goals and objectives, see Table 18 for an explanation of the feedback loop. Our model demonstrates that overriding AI bias decreases trust in the AI model. We chose to model “Override AI Bias” as a variable while also carrying the same name as the loop due to its significance and influence on other variables.

6.5.1.1 AI Explainability and Perception of Project Uniqueness

We find the constant “Non-sufficient AI Explainability” relates to the challenge of the AI black box, where higher machine learning capability typically leads to less interpretability and explainability for the user. Leading to the decision-maker having a limited ability to interpret the reasoning behind the AI output (Arrieta et al., 2020, Gunning and Aha, 2019, Hassija et al., 2024, Hoffman et al., 2018, Saranya and Subhashini, 2023). According to our research, this variable significantly impacts project managers’ bias in overriding an AI analysis. Further, we found that the perception of project uniqueness increased the bias to override AI. This is aligned with the literature suggesting that uniqueness bias is a challenge for project managers (Flyvbjerg, 2021). This is reflected in the AI model's analysis of unique project data, which leads to overriding AI bias and lower trust in the AI model.

To overcome the challenge in explainability, Santos et al. (2023) suggest using the method “Shapley Additive exPlanations” (SHAP) to interpret advanced AI models using Monte Carlo and EVM control techniques. The authors suggest that this method enables managers to interpret AI outputs proactively and retrospectively. Further, Oliveira et al. (2024) propose using SHAP and “Local Interpretable Model-Agnostic Explanations” (LIME) to improve explainability in AI models.

6.5.1.2 Information Asymmetry

Further on, we found that the variable “Information Asymmetry” plays a significant role in enhancing “Misaligned Goals and Objectives”, which in turn increases “Override AI Bias”. In our research context, the asymmetric information is between the project manager and the AI model, where the manager is convinced to have more relevant information on the project goals and objectives than the training data used for the AI model. This leads the manager to believe the AI model is not making a relevant analysis, leading to overriding the AI and taking corrective action. Hence, we suggest that information asymmetry is a root cause of overriding AI bias behaviour. Here, we find our second key contribution, we suggest that “information asymmetry” is a significant cause for DoC and enhances overriding AI bias because the project manager believes the AI model does not adequately analyse the most current information. This can be drawn to the structural determinant of EoC (Sleesman et al., 2012), where the project objective becomes misaligned with the decision-maker’s incentives to complete the project. The bias to override AI shares the influence of information asymmetry with the established behavioural construct “agency theory” causing EoC (Keil et al., 2000). However, in our context, the override AI bias causes DoC. Additionally, the manager and the AI model do not share the roles proposed in agency theory of “the agent” and “the principal” (Jensen and Meckling, 1976, Keil et al., 2000). Therefore, agency theory cannot be directly applied to our research. However, we suggest future research to further study information asymmetry between managers and AI models.

Our third key contribution is related to the second loop in our CLD model. The loop has two unique variables “Trust in AI Model” and “Escalation of Commitment”. We suggest that “Override AI Bias” and “Information Asymmetry” affect managers' trust in AI and are key contributions. We mentioned previously in the discussion section that the manager is affected by information asymmetry and believes the AI model is not performing an accurate analysis. As a result, trust in the AI model decreases due to the override AI bias.

6.5.2 An Outside View

We find similarities in our collected data with the literature suggesting “an outside view” avoids EoC and increases the possibility of taking corrective action (Flyvbjerg, 2013, Haji-Kazemi et al., 2015, Staw, 1981). In our CLD model, we represent an outside view from the constant variable “Project Managers’ Experience” with a positive influence on “Outside View”, which increases the variable “Rework Discovery”.

Our paper suggests that an outside view is based on personal experience. This is aligned with the literature suggesting that learning from previous mistakes is critical for DoC (Chong and Suryawati, 2010, Ku, 2008). However, researchers point out the challenge for project managers

to utilise their experience for DoC as they are limited in their rationality due to the inside view perspective, and a bottom-up approach is applied. Our research is aligned with the literature suggesting that managers who ignore details and utilise a top-down approach enhance their ability to have an outside view (Kahneman and Lovallo, 1993, Kahneman et al., 2011, Lovallo and Kahneman, 2003).

6.6 Implications for Practice

Our research applies to a cross-industry project environment where we included project managers from IT, construction, aviation, and automotive industries. This leads to implications for practice that for the project management community. Our research has three main implications for practice. First, understanding the underlying factors affecting AI trust is necessary to build confidence in the AI model among the project stakeholders. We suggest starting with the available project data and avoiding information asymmetry by continuously training the AI model with relevant data during the project. In addition, practitioners must consider the perception of project uniqueness and adapt the AI model according to the users' need for AI explainability.

Within a reasonable future, we believe AI systems will likely become a standard project management resource, and organisations should prepare stakeholders by setting education development goals to utilise AI decision support systems. Hence, the second implication is for project organisations to invest in AI training to develop knowledge in explainability methods for all project stakeholders, such as the method of SHAP. Team members should be encouraged to augment their decision-making through AI and be trained to use AI methods efficiently and technically safely.

The third implication is understanding the significance of setting a clear protocol for project escalation and de-escalation. Research suggests that DoC traditionally requires a higher level of justification than EoC (Drummond, 1995). However, we suggest practitioners develop clear protocols adapted for escalating and de-escalating projects involving an AI analysis. Such protocol should follow the proposal of Pinto et al. (2022) who suggest considering the context in which the evaluation is made: 1) Who (which stakeholder) is making the evaluation? Depending on the stakeholder's role, the outcome of the evaluation can differ based on their AI knowledge. 2) When is the evaluation made? The evaluation can be affected due to project data being time-dependent. During the project planning, static data makes up the majority of the AI training data, whereas generated project data (dynamic data) becomes available as the project progresses. 3) What criteria is the evaluation based on? Depending on the AI model and data available, some evaluation criteria may be outside the AI model. 4) What type of project is

evaluated, and in which context is the project operating? Here, we suggest practitioners set processes to ensure that high-quality project data and adapt the level of AI explainability according to the project environment.

6.7 Limitations and Future Research

We acknowledge that our research is limited to the specific research context. Due to our data collection being steered to include projects with access to AI training data and where AI systems are used for control analysis, we chose to study a cross-industry environment. We are, therefore, able to generalise our findings. Our selective data collection was necessary due to project managers' limited experience using AI in projects, and we realise this limits the representation of the entire project profession. We invite researchers to challenge our findings and provide more accurate theories explaining project escalation.

Further limitations include our CLD model, which is not an absolute truth or a distinct answer to DoC and EoC behavioural feedback loops. The process of CLD modelling includes deciding on a suitable level of detail. Hence, we have included the most significant variables influencing key categories and themes discovered in our data analysis. This is justified by one of the goals of CLD modelling, which is to explain the causal links on an appropriate level without including redundant variables.

Following our research, we see that AI explainability is crucial for project managers to reduce the risk of overriding AI analysis. Studying specific AI models with different explainability methods and techniques was out of our research scope. However, we suggest future research to examine specific explainability methods to understand their pros and cons in a project context.

6.8 Conclusion

Our research proposes that project managers suffer from bias in de-escalation behaviour when an AI system is used to augment managers' decision-making through project control analysis. We name this bias "Override AI". Given the rapid integration of AI in project management, understanding biases like the one mentioned above is crucial for leveraging AI's full potential. Our research findings are demonstrated through CLD modelling, where variables with causal links make up DoC and EoC feedback loops. Through interviews, we collected data from 22 project managers who had experience using AI analysis as an early warning system to assist during project control. Our research premise is based on managers taking corrective actions

and de-escalating the project by overriding the AI analysis. The paper provides three main research contributions:

1) Our first contribution is the biased behaviour of overriding AI. We find this bias is influenced by “Non-sufficient AI Explainability”, “Perception of Project Uniqueness”, and “Information Asymmetry”.

2) The variable “Information Asymmetry” represents managers’ perception of having more relevant information than the training data used for the AI model. This variable increases “Misaligned Goals and Objectives” and is crucial when managers override an AI’s analysis.

3) Trust in AI is a well-established research area, and we contribute to this literature by proposing further causes for the decrease in AI trust. Our third contribution is the finding that “Overriding AI Bias” and “Information Asymmetry” decrease “Trust in AI Model”.

We see that AI is continuing to undergo rapid development, and it is crucial to understand AI’s role in project decision-making during project escalation. Researching AI in projects requires more attention, and we suggest that fellow researchers continue in this novel field.

Chapter 7 Thesis Discussion

The thesis studies the use of AI in PM through separate research papers and the overall format of the thesis follows the University of Southampton's "research paper PhD". The research findings are presented through three separate research papers, including a SLR in Chapter 4 which reviewed the literature on AI in PM and identified the research gap in studying project managers' decision-making when using AI control analysis. The research gap is explored through two empirical papers studying project managers' behavioural decision-making when using AI-based DSSs for project control analysis in Chapter 5 and Chapter 6. Complementary introduction chapters include PM and OR in section 1.3 and PM and AI in 1.4 demonstrating how the fields of OR and AI have influenced PM through AI optimisation.

Further chapters demonstrate the theoretical framework in Behavioural and Descriptive Decision Theory in Chapter 2. The thesis is based on the premise that project managers use AI analysis as an early warning system during project control and studies their behaviour and decision-making when experiencing project escalation. Based on this, Descriptive Decision Theory is adopted which explains how individuals actually make decisions, rather than the normative perspective which explains optimal decision processes (Einhorn and Hogarth, 1981, Stingl and Geraldi, 2021). Additionally, the thesis describes the concepts of bounded rationality and relates closely to HB. The former explains how decision-makers are limited in cognitive ability to take in all available information to achieve optimal decisions (Gigerenzer, 2004, Katsikopoulos, 2014, Simon, 1972). The latter follows the work by Tversky and Kahneman (1974) who suggest that decision-makers take cognitive shortcuts (heuristics) to ease their decision processes. A negative consequence of heuristics is systematic biases (Bonaccorsi et al., 2020), whereas the related concept of FF challenges HB by not accepting systemic biases. FF relies on fast decision-making through intuition, reflection and learning from previous experience (Gigerenzer et al., 1999, Gigerenzer et al., 2022). HB on the other hand relies on these principles differently and accepts a certain degree of error and biased decisions. The theoretical framework demonstrates the perspective of BOR. This research area focuses on understanding project managers' behaviour through the BOR perspective of "behaviour with models", meaning that the thesis studies individuals' decision-making and their behaviour when using AI-based OR tools for project control.

Further on, the research methodology in Chapter 3 presents an interpretive philosophy and subjectivist ontology, followed by a constructivist epistemology and a Grounded Theory research strategy. The data collection is based on interviews with 22 project managers with experience of using AI analysis as an early warning system for project control. The qualitative

data is analysed based on three coding steps: open, axial, and selective coding. The participants were from the automotive, aviation, construction and IT project industries. The cross-industry environment allows the thesis to generalise the findings and apply them to a cross-industry project environment.

The thesis' tangible contribution includes two behavioural constructs based on project managers' biased decision-making when using AI analysis for project control. The constructs are named "the wait effect" and "override AI bias". The wait effect expands EoC literature, whereas override AI contributes to DoC literature. The thesis highlights the significance of "trust in AI" in mitigating these biases. Additionally, the thesis contributes with a synthesis of the literature on AI in PM and a proposed agenda for AI in PM research. The discussion chapter explains why the findings are significant, their contribution to theory and their implications for practice. The findings from the three research papers are significant to the project literature. The main theoretical contribution is advancing the current knowledge of AI in PM and extending the BOR literature through the lens of behaviour with models. The main implications for practice are managers' awareness of biased behaviour when using AI analysis and the suggested variable of trust in AI to mitigate the behavioural constructs of the wait effect and override AI.

7.1 Systematic Literature Review Discussion

The SLR aims to answer the following research questions:

What themes define project management and AI literature? What trends can be identified in the project management and AI literature? What future research agenda can be identified from project management and AI literature?

The SLR demonstrates that project research in AI has changed throughout the years and researchers' choice of methodology has reflected the development of AI technology. Specific methods have been used during specific periods. 1) Early researchers presented a conceptual discussion based on the challenges, risks and potential of AI in PM. The conceptual approach is justified through early AI in PM research limitation in analytical ability due to limited available project data and low maturity in applying AI to project areas, e.g. Levitt and Kunz (1987) presented a conceptual paper on how the field of AI in PM would enable more efficient objective setting, planning, scheduling, and control through AI expert systems.

2) When AI's analytical ability and accessibility increased, PM and OR researchers were able to realise the potential of AI through single AI model optimisation of project knowledge areas. 3) Further technical advancements allowed for the optimisation of project areas through hybrid AI models. AI optimisation of project areas is closely related to the field of OR and applying a single

AI model demonstrates the benefits and challenges of specific algorithms. In contrast, a hybrid AI model is based on multiple models complementing each other to solve a specific problem. This finding is aligned with the literature suggesting that OR has contributed significantly to the field of PM through mathematical optimisation (Tavares, 2002). The SLR presents that AI optimisation is often performed on typical OR areas including project planning and control. Some publications compare the results of AI models. This is critical when identifying the most efficient AI model for a specific problem. Further, it is critical to create replicable studies of AI models for other academics to include in their own research. Replicable research can be achieved through openly shared AI models and data.

4) The SLR presents that contemporary publications commonly apply empirical research by studying project practitioners' perceptions and use of AI technology through quantitative questionnaires or qualitative interviews (Fridgeirsson et al., 2021, Holzmann et al., 2022). Additionally, empirical research is conducted on potential knowledge areas. Fridgeirsson et al. (2023) suggest that areas involving the management of teams and human interaction will have the least impact from AI. Further empirical studies suggest that agile leadership can benefit the implementation of AI in projects (Tominc et al., 2023). The categorisation of the above methodological themes is a theoretical contribution that guides project researchers in understanding which approach is suitable for their research and allows them to identify publications related to their topic.

Further contributions from the SLR include identifying which industries are applied in project research. The SLR demonstrated that the construction project industry is overrepresented through e.g. Kumar et al. (2021) who studied success factors for implementing AI in construction projects and suggested critical drawbacks of AI, such as the lack of ability to interpret information as humans. The role of data in the construction industry is discussed further in the suggested research agenda related to project data in section 7.5. Additionally, a key contribution is the identified research gap in studying project managers' behaviour and decision-making when using AI-based DSS for control analysis, which formed the main research question.

7.2 Empirical Research Contributions

Based on the research gap, the thesis formed the main research question: *How do behavioural theories or constructs affect project managers during the project control process when using Artificial Intelligence technology as early warning sign tools?*

The main research question was answered through two empirical research papers. When studying the main research question, it became evident that the phenomenon of EoC is central to project managers' behaviour when using AI analysis. EoC behaviour is an established HB among project managers (Keil et al., 2007, Berente et al., 2022, Sleesman et al., 2018, Staw and Ross, 1987). However, it has not been studied extensively in the context of AI-based DSSs. The empirical papers demonstrate two sides of project escalation, EoC and DoC when using AI as an early warning system for project escalation. As mentioned previously, the papers present the two main findings of this thesis, namely the behavioural constructs of "the wait effect" and "override AI bias". The constructs are complemented with the critical variables of "trust in AI", "willingness to take corrective action", "perception of project uniqueness", "confidence in original project plan", "anchoring to project data" and "information asymmetry".

The wait effect explains EoC, based on the premise that the manager is hesitant to follow the AI's warning signal indicating project escalation. Overriding AI bias explains how managers take corrective action and de-escalate the project regardless of whether the AI analysis indicates such a warning sign. These constructs and variables are discussed in the next sections.

7.2.1 The Wait Effect

The wait effect is a significant contribution to the BOR literature. This behavioural construct explains why project managers experience EoC behaviour when using AI systems for project control and are hesitant to follow the AI analysis when it suggests taking corrective action against project escalation. Together with other established EoC constructs of prospect theory (sunk cost effect), approach-avoidance theory (completion effect), and agency theory (goal incongruence), the wait effect compliments the explanation of project managers' EoC behaviour. This is a significant contribution to theory and expands the theoretical understanding of the phenomenon of project escalation. A further contribution is the definition of whether "to do nothing" is considered an action or inaction (Feldman and Wong, 2018). The wait effect is suggested to be used as a definition when managers are hesitant to act. Additionally, the wait effect is an addition to the psychological determinant by Sleesman et al. (2012) where the EoC constructs of prospect theory and approach-avoidance theory are categorised.

The wait effect occurs due to two conditions: 1) confidence in the original project plan, and 2) low willingness to take corrective action based on a low trust in the AI model, see Figure 13 on page 101 for the full CLD model presenting the wait effect. The findings suggest that confidence in the original project plan is influenced by an anchoring process to project data and the perception of project uniqueness. Anchoring is established in the literature as an emotional attachment which ignores statistical (Lovallo and Kahneman, 2003, Son and Rojas, 2011). The

thesis suggests adding anchoring to the project control phase, which challenges previous literature that categorises anchoring as a project planning activity (Wang et al., 2020b). This suggestion is justified based on the fact that the anchoring process is an emotional attachment that is not limited to a singular project phase and is shown to affect managers' behaviour during project control through the wait effect. Moreover, the thesis suggests that using AI training data from the current project enhances the anchoring process to the new project data. In turn, this decreases the confidence in the original project plan, which is based on static data prior to the project initiation. This is aligned with the literature, suggesting the use of dynamic data based on empirical and artificial data generated from the actual project rather than static data (Vanhoucke et al., 2016).

Further on, the perception of project uniqueness makes managers believe that their project is unique to an extent where external project data is considered irrelevant for AI training. This is aligned with the literature suggesting the significance of project uniqueness bias (Flyvbjerg, 2021, Flyvbjerg et al., 2024). The thesis suggests that the perception of project uniqueness is acceptable to a certain extent due to the fact that projects have unique characteristics in terms of e.g. objectives, team dynamics, and schedule. However, it is suggested that uniqueness bias is given a disproportionate weight in managers' decision-making.

Moving on, the second condition for the wait effect is managers having a low willingness to take corrective action and low trust in the AI model. These variables are highly dependent on each other. The significant role of trust in AI is crucial in project managers' behaviour and is aligned with the literature suggesting it is critical for AI users to have trust in this technology (Ali et al., 2023, Glikson and Woolley, 2020, Mahbooba et al., 2021, Rossi, 2018).

7.2.2 Override AI Bias

The second main contribution of the thesis is the behaviour construct of override AI bias, see Figure 16 for full CLD model of this construct. The premise for this heuristic is when the manager believes the project is escalating and takes corrective action regardless of whether the AI model indicates such a warning sign. This is a significant contribution to the project literature and BOR. It adds to the DoC literature which has seen limited attention compared with the literature of EoC (Pala et al., 2015, Pan et al., 2006). The thesis suggests adding this behavioural construct to the psychological determinants proposed by Sleesman et al. (2012).

The main condition for this construct is information asymmetry and is related to agency theory where an "agent" serves as the decision-maker on behalf of a "principal". Information asymmetry explains the scenario in which the two roles have misaligned information. Agency theory causes EoC based on the agent acting according to the given information and personal

agenda (Keil et al., 2007). Similarly, when override AI bias occurs, managers believe they have more relevant project information than the AI model based on recent project updates have not been reported to the AI system. The thesis suggests expanding the application of information asymmetry to include DoC when the AI and the manager are misaligned. The thesis suggests that information asymmetry decreases trust in AI models and is further discussed in section 7.5 on page 138, when discussing how to develop trustworthy XAI models.

Another variable influencing override AI bias is AI explainability, i.e. XAI. De Bock et al. (2024) suggest categorising XAI in OR based on performance, attributable, and responsible analytics. The framework of De Bock et al. (2024) is significant for this thesis based on the close connection between AI optimisation for project areas and OR. The thesis includes the performance and attributable perspectives, whereas responsible analytics is out of scope for the thesis. The performance perspective involves traditional OR optimisation and is included in the thesis through the literature review identifying AI optimisation of project knowledge areas and through the premise that project managers use an AI-based OR tool for control analysis. According to De Bock et al. (2024), performance analytics is a minimum requirement for XAI. The thesis emphasises the suggestion of De Bock et al. (2024) to focus on achieving efficiency and effectiveness of the optimisation problem for high-performing XAI. For attributable analytics, the thesis suggests including elements of explainability and emphasises managers' trust in AI as a key attribute of XAI. A further discussion related to XAI attributes is found in section 7.5 when discussing how to develop trustworthy XAI models. It is further recommended that project researchers continue studying specific attributes of XAI models and expand on suggested attributes in the literature including understandability, justifiability, actionability, fairness, unbiasedness, causality, trustworthiness, causality, and transferability (De Bock et al., 2024, Barredo Arrieta et al., 2020, Doshi-Velez and Kim, 2018, Miller, 2019).

7.3 Mitigate Bias Behaviour Through Trust in AI

The literature on trust in AI is a well-established research area and this thesis contributes to the literature by proposing further variables affecting AI trust (Ali et al., 2023, Cabiddu et al., 2022, de Brito Duarte et al., 2023, Feher et al., 2024). The thesis suggests that trust in the AI model mitigates the biased behaviour of the wait effect and override AI bias.

Project uniqueness is a significant bias among project managers that decreases the trust in AI. It is an established bias in project literature (Flyvbjerg, 2021). If managers can see beyond the specific project's unique characteristics and highlight the commonalities between projects, then the perception of project uniqueness is avoided. The thesis suggests educating practitioners on uniqueness bias through increasing the awareness of this behaviour. Further, a

practical suggestion is to reduce uniqueness bias through reference-class method based on comparing the actual project with historical projects to identify commonalities.

The thesis follows the proposal of Vanhoucke et al. (2016) suggesting the use of dynamic project data for AI training, and it is suggested to increase trust in AI. The increase in trust is based on the finding that managers believe the AI performance increases when the AI is trained on the most current data. However, this depends on the data quality and it is critical to use dynamic data and ensure high-quality data processes to increase trust in AI. To enhance trust, it is critical to establish a sufficient level of AI explainability and avoid information asymmetry. It is suggested that the project community focuses on developing XAI models with attributes that enhance explainability and mitigate information asymmetry. This is discussed further in the suggested research agenda section 7.5 on page 138.

7.4 Theoretical Model of AI in Project Management

The thesis presents a theoretical model, see Figure 17, demonstrating variables influencing project managers' biased behaviour when using analytical XAI models. The theoretical model is developed based on Descriptive Decision Theory and the concept of HB. The proposed theoretical model is named "The Weighing Scale of Project Managers' Heuristics and Biases with Explainable AI" and is illustrated as a weighing scale where the root causes of project uniqueness, information asymmetry, insufficient AI explainability, and insufficient project data management are weighed against the mitigation variable of trust in AI model. If the root causes outweigh the AI trust, the HB behaviour of the wait effect and override AI bias will occur. The model is a significant contribution to the literature on BOR and the greater theory of Descriptive Decision Theory. Further, the model suggests how project managers can mitigate bias behaviour in a project control context, additionally the model contributes to Prescriptive Decision Theory when an ideal decision outcome is aimed for. The scope of the thesis was to study individual project managers' decision-making, however, the model is useful in an organisational context where information asymmetry may occur through different information is given to the manager and the AI due to organisational issues.

The suggested theoretical model adopts HB and the key concept of bounded rationality, which is a well-established concept in Behavioural Decision Theory (Simon, 1972). Bounded rationality suggests decision-makers are limited in their cognitive ability to absorb all available information to make an optimal decision. The concept of HB acknowledges biased behaviour based on individuals' decision-making is simplified with a "good enough" mentality. The effort put into the decision process is relatively low in relation to the efficient decision process and "good enough" results (Stingl and Geraldi, 2021).

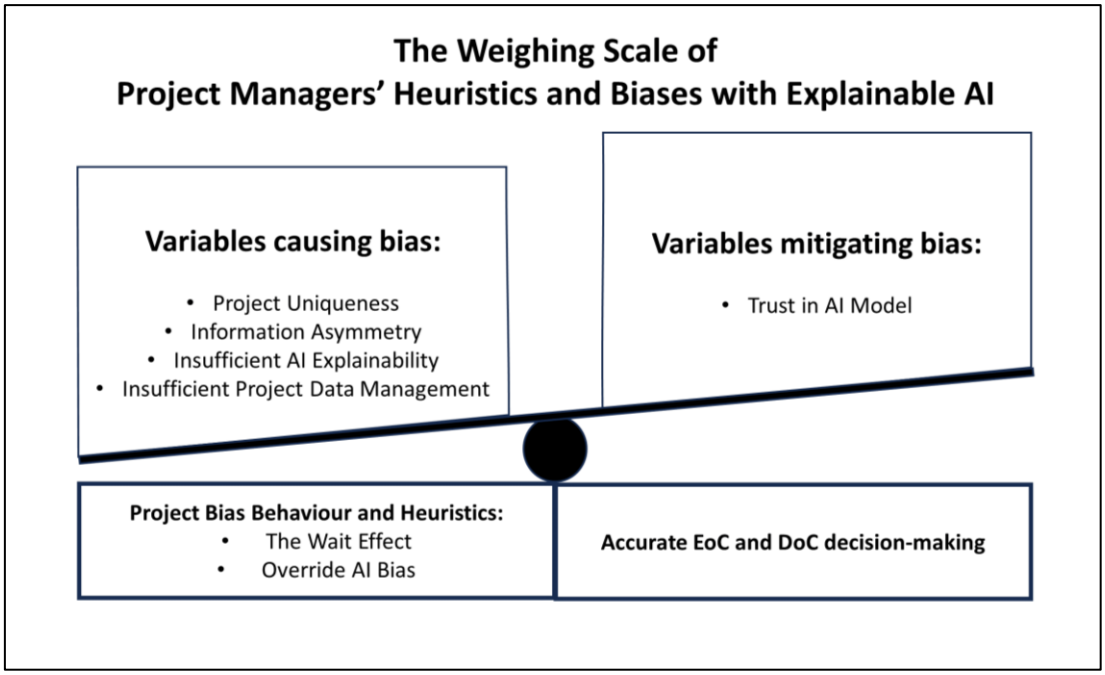

Figure 17: The Weighing Scale of Project Managers' Heuristics and Biases with Explainable AI

The model is suggested as a foundation for project researchers studying managers' behaviour when using AI through the lens of XAI and BOR. Academics are invited to challenge or expand the model through additional variables and biased behaviour. Practitioners are invited to use the model to understand what variables drive and mitigate biased behaviour.

It is necessary to reflect on the change management process required for a successful implementation of AI. Idogawa et al. (2023) suggest critical success factors for business change processes are "project management", "top management support" and "technological competencies". The suggestion that "project management" is a success factor is an opportunity for the project community to utilise the PM skills among project professionals. There are several models mentioned in the literature for change managers to adopt, e.g. Kotter's 8-Step Model, Lewin's 3-Stage Model of Change, McKinsey 7S Model of Change, Rogers Diffusion of Innovation Theory, and Prosci ADKAR (Harrison et al., 2021).

7.5 Agenda for the Project Community Implementing AI

Moving on, one of the main contributions of the SLR is the proposed research agenda, which is complemented by the empirical papers. This discussion section elaborates on the agenda and sets clear objectives for the project community to achieve: 1) Increase the number of empirical publications studying project managers' decision-making and use of AI. 2) Continue optimising project knowledge areas through AI-based OR research. 3) It is critical for academics and practitioners to develop project data management skills. 4) Closer collaboration between

practitioners and academics. 5) The need for the project community to develop high-performing and trustworthy XAI models.

1) The SLR demonstrates that contemporary publications conduct empirical research on project managers' perceptions and use of AI through qualitative or quantitative data collection. This thesis proposes to continue conducting empirical research on project managers' use of AI, and specifically study project managers' decision-making when using AI systems. Researchers are suggested to study managers' decision-making process when applying advanced machine learning and AI models with the "AI-black box" challenge. This thesis conducted two empirical research papers based on this suggestion through the lens of BOR. Future research on AI in PM is suggested to expand on all of the BOR perspectives, including "behavioural in models" and "behaviour beyond models". The former involves studying the decision-maker as part of the behavioural model. For this purpose, it is useful to adopt a macro perspective and potentially study the manager as part of a project stakeholder network. It would be interesting to study AI in PM from a multi-stakeholder perspective and multi-project environment. A behavioural model may answer the question: "What behavioural constructs occur during projects in a multi-project stakeholder and multi-project environment?". The latter perspective, behaviour beyond models, allows the PM community to understand decisions outside the model's parameters and suggest policy-making guidelines based on managers' needs and behaviour. Setting policy guidelines for AI in PM is critical to establishing long-term successful AI implementation.

2) The second recommendation is for researchers to continue using AI to optimise project knowledge areas. It is suggested that researchers target specific challenges in AI models related to XAI. This can include the suggested variables of AI explainability, project uniqueness, data generation, and information asymmetry. The thesis suggests that other researchers challenge and expand the understanding of what variables influence AI trust. Additionally, it is recommended that academics expand traditional OR research to study how to optimise areas such as stakeholder and knowledge management (Holzmann et al., 2022, Li et al., 2021, Mueller et al., 2024, Zheng et al., 2021, Bahi et al., 2024). On the other hand, these areas experience challenges in available AI training data to be used for analytical AI (Fridgeirsson et al., 2021, Kumar et al., 2021). As a complement to analytical AI, the SLR demonstrates the use of generative AI in PM. The SLR identifies that analytical and generative AI are used for different purposes. Project areas such as knowledge management can benefit from generative AI by improving workflow processes through automating repetitive tasks or analysing and creating project documents (Barcaui and Monat, 2023, Karnouskos, 2024). The characteristics of generative AI differ from analytical AI through having a low entry threshold, being highly accessible through e.g. Chat GPT, and requiring relatively low investments of resources to see acceptable results (Felicetti et al., 2024). Meanwhile, analytical AI typically requires advanced

technical skills and a developed knowledge of AI algorithms. Aligned with the literature by Nyqvist et al. (2024) the thesis suggests that project managers adopt generative AI to take advantage of the low-hanging fruit to optimise and automate repetitive tasks while investing long-term in analytical AI for project analysis.

3) The third recommendation suggests that the PM community develop skills related to project data. This involves creating dynamic project data, policymakers setting up incentives for organisations to harness, store, and share data, and investigating the question of data ownership. These areas are discussed further below.

The literature discusses dynamic and static project data (Vanhoucke et al., 2016). The mentioned authors suggest using dynamic data based on empirical or artificially generated data from project simulations, over static data. The thesis suggests that project practitioners understand how to manage and generate high-quality empirical data and develop skills in generating artificial data through project simulation. The project community should educate project managers about generating artificial data through simulation tools e.g., Earned Value Management (EVM) and Monte Carlo simulations.

From a business perspective, the thesis suggests that policymakers develop incentives for organisations to invest in data management and AI technology. The resources for setting up data management processes need to be justified from a long-term business perspective. The SLR demonstrates that construction projects are overrepresented in AI in PM research. This is partly due to standardised building processes creating reusable project data. A standardised process is critical to harness reusable data and data storage. Although the construction industry demonstrates well-suited processes to share project data, it is currently not done on a large scale (Martínez-Rojas et al., 2016). It is suggested that construction sites struggle to implement technology based on human limitations on management performance and poor use of available technology (Ozumba et al., 2019). One method to improve construction data is “Reality Capture”, where a 3D model is produced with complementing data. This method improves efficiency in areas such as quality assurance and monitoring project control (Fobiri et al., 2022).

Further on, policymakers need to create incentives for organisations to manage and share data to be reused between projects and organisations. The thesis highlights that sharing data between businesses is a complex process that involves technical and business perspectives. Technical challenges relate to the previously mentioned harnessing and storing reusable data. Business challenges include companies investing in data processes without incentives to share data between organisations may lead to companies losing their unique selling points. The thesis suggests that organisations enter partnerships in which multiple organisations follow a set of

guidelines based on, e.g. data quality and project data type. An example of such a partnership is a building contractor sharing scheduling data and other relevant information with the PM company managing the construction site. Through such partnerships, businesses will benefit from harnessing project data from other companies while knowing the data is reusable.

The thesis suggests that policymakers collaborate with academics to investigate data ownership and the possibility for organisations to share data. It currently involves questions regarding data ownership where it is uncertain who owns the data in a multiple-stakeholder environment, e.g. is it the client, project organisation or the contractor who owns the data generated from the project? The literature on data ownership highlights several challenges, including how data is recognised and redistributed (Hummel et al., 2021). The mentioned authors emphasise the need for various data control methods to comply with current interpretations of data ownership. Further, the field of data is poorly defined while critical for technical innovation and has become a value and service in itself involving multiple stakeholders (Asswad and Marx Gómez, 2021). With these challenges in mind, policymakers need to set guidelines for the project community based on a long-term plan and for the benefit of the greater project community. This thesis suggests incentivising long-term data storage and sharing data between projects and organisations to avoid an individualistic mindset.

4) Collaboration between researchers and practitioners is critical for achieving the above agenda. Although PM and AI have been studied since the 1950s as separate fields, the combined area of AI in PM is still in its infancy. The fact that it is not a well-established field in practice or academia highlights the significance of sharing AI knowledge, AI training data, and best practices. Collaboration between practitioners and academics is crucial for researchers to access real project data to train AI models and for practitioners to access AI models developed by academics. This thesis points out the critical aspect of project data, and it becomes evident that project data is scarce and experience in using AI for projects is limited. To create incentives for practitioners to engage in academic research, the thesis suggests academics create tangible contributions for practitioners through AI optimisation of project knowledge areas and develop OR techniques through the perspective of BOR.

5) The fifth point emphasises the need for the project community to develop high-performing and trustworthy XAI models. According to the BOR literature, it is significant to understand AI further (Kunc and Katsikopoulos, 2022). This includes the attributes project uniqueness and information asymmetry in the theoretical model, Figure 17 in section 7.4. A future research question may be: “How can XAI models in project management help managers avoid the perception of project uniqueness?” To increase the level of explainability, it is suggested that AI developers and researchers study XAI models’ ability to provide the data source for the AI

analysis. Further on, a research question addressing information asymmetry may be: “How can XAI in project management consider information asymmetry?” The thesis suggests that information asymmetry leads to DoC behaviour in the form of override AI bias. This occurs when the AI and project manager apply misaligned information for the control analysis. The thesis suggests developing XAI models with the ability to provide a data record including the date, time, and history of the AI training project data. Additionally, XAI models should include AI training data based on “live” project data or as close to live data as possible.

Additional questions addressing managers’ needs and behaviour when using XAI models include: “How can XAI algorithms be made to comply with project managers’ decision-making heuristics and biases?” Further understanding of the black box trade-off can be done by asking: “What XAI attributes are critical to avoid the AI black box trade-off?” And: “How can decision-making consider XAI attributes and responsible ethics while developing high-performance AI analytics?” Developing AI models with adequate explainability is critical because it allows project managers to develop sufficient trust in the AI model. The trade-off between high analytical ability and low explainability brings complexity to this area and is necessary to study further. Additionally, it is relevant to explore follow-up studies through other methods such as in-depth case studies or quantitative studies.

It is suggested that establishing a sufficient level of trust mitigates the biased behavioural constructs presented in this thesis. The connection between XAI and users’ trust in AI is aligned with the literature (Mahbooba et al., 2021, Ali et al., 2023). More specifically, Ali et al. (2023) suggest the following classifications of explainability based on “data-”, “model-”, “post-hoc-”, and “assessment explainability”. The thesis suggests that future researchers adopt this categorisation of explainability and adjust it towards project research. Further on, the attribute of visualisation of the AI analysis is suggested to increase confidence and trust in the AI (de Brito Duarte et al., 2023). Additionally, displaying the AI analysis confidence in percentage and providing multiple answers as alternatives increase users’ trust (Gkinko and Elbanna, 2023). Project researchers are suggested to adopt the Technology Acceptance Model (TAM), which is aligned with literature studying users’ perceived usefulness of AI (Choung et al., 2023, Kelly et al., 2023).

Understanding the end-user and its demography is crucial when developing AI models. The perception of AI from a European demography is studied by Omrani et al. (2022) who suggest that men generally perceive AI more positively than women. The same authors suggest that unemployed individuals trust AI more than other groups, and elderly people tend to trust AI technology more than young individuals. Whereas high-income groups trust AI systems the least. However, this is misaligned with the findings of Lee and Rich (2021) who suggest that poor

socioeconomic groups have lower trust in AI. Additionally, geographical demographics show that Germany, Luxembourg, Slovenia, and the UK have less trust in AI systems than other European countries (Omrani et al., 2022). This is critical information for project academics when analysing data collected across country borders and socioeconomic groups as the findings will most likely reflect the participants' social status. Also, it is significant for business organisations that offer AI services to understand that the perception of AI trust for the intended user differs based on demographics.

Challenges for developing XAI models include legislation to make AI systems more transparent. Researchers highlight that the area of XAI is elusive and XAI legislation can potentially create a false sense of security (Chung et al., 2024). The discussion of AI legislation includes the argument to protect users from unethical use and personal integrity. On the other hand, it is argued that too much legislation hinders AI development. The thesis suggests that AI legislations are continuously reviewed to analyse the effects on individuals, business organisations and the greater good of society. Further challenges in developing XAI models include biased AI training data sets (Rossi, 2018). The mentioned author highlights the need for built-in bias detection in AI systems. Discussing this area in detail is out of the scope of this thesis. However, this thesis follows the proposal of De Bock et al. (2024), suggesting it is critical for XAI research to include responsible and ethical AI analytics.

With new AI technology, such as generative chatbots, the user is given more influence on the AI output. Traditionally AI models are influenced or steered by the programmer. However, generative AI models are steered by the user's prompts, which affects the AI output, e.g. the user can command Chat GPT to provide an output with a certain tone or written style. Researchers suggest that AI trust is affected by the stakeholder who is influencing the AI model's goal and objective (Saffarizadeh et al., 2024). The research by Saffarizadeh et al. (2024) suggests that trust in the AI model increases if the model's creator, i.e., the programmer, has sole access to the model's goals. Whereas trust in the AI decreases when the user is given access to the model's goals. The thesis suggests that project researchers adopt this research premise and study how different project stakeholders influence trust in analytical XAI models.

Georganta and Ulfert (2024) suggest that team members' trust in an AI colleague increases when the AI performance is reliable and sustained. This leads to "performance consistency" as a potential XAI attribute to be studied. An additional key attribute discussed in the literature is "anthropomorphism", i.e. human-like features (Chen and Park, 2021, Glikson and Woolley, 2020). The mentioned authors suggest there is a connection between trust and human-like attributes. This may have further implications when AI is used as a team member and colleague (Dennis et al., 2023).

Chapter 8 Thesis Conclusion

This thesis studied project managers' decision-making and behaviour when using AI-based DSSs for project control analysis. Central to the research is project managers' experience of the phenomenon of EoC. This phenomenon is well-established in the project literature and explains when the project manager continues to invest in the project while warning signs indicate corrective action is needed. The thesis' main contributions consist of the behavioural constructs of the wait effect and override AI bias, which explain project managers' biased behaviour of EoC and DoC when using AI as an early warning system for project control.

The main research question was formed through the SLR, where the thesis identified research gaps by synthesising the literature on AI in PM. The main research question is answered through empirical research papers and is based on 22 qualitative interviews with project managers having experience using AI for project control analysis. The following chapter summarises the thesis findings through theoretical contributions and implications for practice and presents the research limitations and recommendations.

8.1 Theoretical Contribution to Knowledge

The main theoretical contributions are summarised to include: 1) The theoretical model in Figure 17, section 7.4, demonstrating project managers' behaviour when using XAI models. The theoretical model is named "The Weighing Scale of Project Managers' Heuristics and Bias with Explainable AI" and presents variables that cause and mitigate the biased behaviour of the wait effect and override AI bias. The model significantly contributes to the BOR body of knowledge and adds to the theories of EoC and DoC, as well as to descriptive and prescriptive decision theory.

2) The thesis contributes to EoC and DoC theory in project management through the behavioural constructs of "the wait effect" and "override AI bias". The thesis suggests that the wait effect is dependent on two conditions enforcing EoC. The first is project managers' having high confidence in the original project plan, and the second is managers' low willingness to take corrective action due to a low trust in the AI model. Override AI bias is influenced by information asymmetry representing DoC, this expands the application of information asymmetry beyond the established EoC-based construct of agency theory.

3) The future agenda and synthesis of the literature on AI in PM is a key theoretical contribution presented in section 7.5, where the thesis highlights the critical need to develop trustworthy XAI model through future research. The SLR provided a structured synthesis demonstrating suitable

methods for project researchers to adopt. The categorisation of the methodological themes guides academics in their choice of research methods and allows them to identify further publications related to this topic. The research agenda suggests that academics continue to optimise project areas through AI and apply empirical research to study the research gap in project managers' decision-making and behaviour when using AI.

8.2 Implications for Practice

The practical implications include the applied behaviour of the constructs the wait effect and override AI. This includes the suggested variables causing biased behaviour: 1) project uniqueness, 2) AI explainability,3) generated project data, and 4) information asymmetry. The thesis suggests that the above variables affect trust in the AI model. There are several practical implications for practitioners in ensuring a sufficient level of AI trust, which is suggested to mitigate the mentioned behaviour constructs.

1) The variable of project uniqueness is suggested to be a significant bias among project managers, and this thesis suggests it decreases trust in AI. To avoid the perception of project uniqueness managers should see beyond the unique project characteristics and instead focus on the similarities between different projects. For this purpose, the thesis suggests project methods such as reference class forecasting and bench marking, where data from projects within the same category are compared with the actual project.

2) It is significant for practitioners and AI developers to ensure sufficient AI explainability. The XAI attributes related to the AI black box challenge depend on the individual project manager and the specific AI knowledge. It is suggested that practitioners adjust the AI model and consider the choice of AI model based on attributes of explainability through user-centered development, not solely on analytical AI ability.

3) It is critical to create well-suited data management processes. Generated project data, or dynamic project data, increases trust in AI. This is based on the finding that project managers believe AI performance improves when the AI model is trained on the most current generated data. However, this depends on the data quality, and it is critical to implement data management processes that ensure a sufficient level of trust in AI.

4) The findings suggest that information asymmetry decreases trust in AI, and it is critical for practitioners update AI training data sets at the same speed as the project manager receives information. The thesis suggests that practitioners develop XAI models with the attribute of data records and data history.

Further implications include project organisations and policymakers. Organisations that invest in AI and data need to consider a long-term perspective, and policymakers are suggested to develop incentives for organisations to invest in data management and AI technology. The SLR demonstrated that, historically, project researchers have focused on studying AI in the construction project industry. An argument for this is the generation and reusable project data created from construction projects. Policymakers need to encourage organisations in multiple project industries to harness and generate reusable data to be shared between projects and organisations. The thesis suggests that policymakers set principles on data ownership and enable organisations to share data through partnerships. The thesis suggests that the project community educate practitioners on data management and processes to secure high-quality and reusable project data.

8.3 Limitations and Recommendations

The thesis contributes through significant findings, however, the research has several limitations. These include the qualitative research method involving the participants' backgrounds in terms of AI knowledge, their cross-project industry background, and their demographical background. Further limitations include the overrepresentation of project researchers studying the construction industry and the risk of rapid development of AI, causing the thesis' research findings to become outdated when new AI technology replaces previously used AI tools. These limitations are presented below.

It is important to consider that the thesis' qualitative method has limitations and the research findings should not be applied to other PM contexts. The richness of the in-depth data is a strength and the research findings are validated through additional data collection. However, it is limited in generalising other than the studied circumstances.

During the sampling of the interview participants, their knowledge of AI was established by verifying that an AI model was used for control analysis. The AI analysis was either interpreted directly by the project manager or interpreted by a data analyst assisting the manager in this task. The fact that, in some cases, the manager is receiving second-hand information regarding the AI analysis via the data analyst may cause limitations in the research findings. The data analyst may unintentionally interfere in the interpretation of the analysis through their personal bias. To mitigate such influence, the interviewees confirmed that the analysis is interpreted by several individuals and not by one person alone. This limitation may misrepresent project managers' behaviour when using AI-based DSSs for project control. However, it is suggested that this does not significantly impact the thesis' findings since the data reached saturation from multiple interview participants.

The generalised findings in a cross-industry environment limit the thesis from conducting deep research on a specific industry. However, the cross-industry perspective allows the thesis to reach a broader audience in the PM community. The findings are suggested to work as a foundation for academics and study specific industries where the thesis' findings are enhanced or challenged. The cross-industry perspective is justified by the typical characteristics of projects as unique and temporary endeavours with common traits, such as having a clear starting and ending point performed by a temporary team setting.

A further limitation of the generalised findings is the demographical background. The research by Lee and Rich (2021) and Omrani et al. (2022) suggest that different perceptions of AI depend on individuals' origin and socio-economical background. However, studying the relationship between demographics and managers' decision-making with AI was out of scope of this thesis. The thesis invites future academics to study the relationships between demographics and managers' decision-making with AI. The varied use of AI in projects was evident early in the participant sampling process. When contacting participants, many of them showed high interest in AI and agreed to discuss the topic. However, not all demonstrated experience in using AI. It was significant to ensure the participants had experience using AI in projects. When the thesis research began in 2019, it became evident that the project community experienced low AI maturity. This led to the interview participants being early adopters of AI technology, working in organisations or industries with these ambitions. This is a limitation in terms of representation of the project management profession. However, this limitation is aligned with the exploratory nature of the research topic and a targeting sampling technique. The thesis highlights the interview participants were active in industries which can be considered early adopters of AI in PM. It is suggested that future researchers study project industries which are laggers in this technology.

Additional limitations involve the SLR. The writing of the SLR paper began in the autumn of 2019, and the field of AI in PM needed a structured synthesis and research agenda. Since then, the field has seen publications reviewing specific project industries and AI techniques. However, this thesis' SLR contributes with an overview of project research and AI and a specific agenda for the PM community. The SLR demonstrated that the construction project industry is overrepresented in AI and PM research. In the initial SLR search process, the thesis' author discovered the mentioned overrepresentation and the search string was analysed to mitigate bias. Additionally, the author discussed the search string with academic colleagues. However, the author decided to continue the search as the search string did not demonstrate any obvious bias.

The rapid progress of AI techniques and the fast adoption of new AI technology have the potential to make the thesis' research findings less significant. Given that generative AI has become widely used in a short time, it becomes challenging to predict the future development of AI. Most likely, analytical and generative AI will complement each other. In the future, it is suggested that more advanced AI has the potential to outperform current AI technologies. The thesis encourages the development of new AI technologies and suggests that the thesis findings are challenged and adopted for future research in project managers' decision-making when using AI.

8.4 Future of AI in Project Management

To finish the thesis, the author takes the freedom to discuss the future of AI in PM. It is evidently that it is extremely difficult to predict the future of AI technology and it is argued that the expectations of AI technology are ahead of the development itself (Goodwin, 2018). Viewing the AI development, the interest in AI fluctuates between high optimism i.e. "AI spring", and pessimism i.e. "AI winters" (Cubric, 2020).

Considering the increased interest of AI in PM since this thesis research began in the autumn of 2019, it is intriguing to imagine the development of AI in PM in the years ahead. In recent years, analytical AI has seen progress through business applications and research publications. The entrance of generative AI has challenged how project managers and team members perform tasks involving project documentation and analysis of project documents (Barcaui and Monat, 2023). However, there are risks related to the intense attention given to generative AI, where project organisations focusing solely on adopting this type of AI are limited in their resources for adopting analytical AI. Hence, the project community should continue focusing on optimisation and analytical AI.

This thesis studies analytical AI while mentioning generative AI. According to the overall AI discussion, some researchers suggest that within a few decades, Artificial General Intelligence (AGI) will significantly increase AI's capabilities and is suggested to outperform the human brain in analytical capabilities (Goertzel, 2014, McLean et al., 2023). A simple definition of AGI is "strong AI", whereas analytical AI is defined as "weak or narrow AI" (Russell and Norvig, 2016). Current research on AGI in PM is limited, hence, this discussion includes the wider AGI literature. The findings from McLean and colleagues' (2023) review suggest that the risks of AGI include the ability to remove itself from human managers' control, the development of unethical AGI, and inadequate management of AGI. The mentioned authors suggest this will cause existential risks to human society. Combining AGI with the internet-of-things introduces further risks and challenges for society which require immense future research (Dou et al., 2023).

Bubeck et al. (2023) suggest that Chat GPT 4 can be considered an incomplete AGI due to its ability to answer a wide range of questions and create material related to mathematics, coding, medicine, law, and more. However, this thesis suggests Chat GPT is not to be considered AGI because the quality of GPT's answers is not completely accurate.

As a final discussion, the thesis suggests that generative AI will complement and improve the use of analytical AI in PM. However, the entrance of new technology brings an inherent risk of professional roles being replaced. Analytical and generative AI are used for different purposes and the technical development of generative AI demonstrates the benefits of automating time-consuming and repetitive tasks. These project activities are commonly performed by entry-level roles, project support and assistant roles that risk being replaced by generative AI. However, this type of AI requires a specific set of skills in prompt writing, leading to opportunities for early adopters to learn these critical new skills. This thesis suggests that analytical AI may replace or enhance project managers' analytical tasks. Further, the thesis suggests that the project manager is not in danger of being replaced by generative AI or analytical AI in a short-term perspective. Additionally, the thesis suggests that the project manager's role in coordinating project activities and team members through stakeholder management is cemented as a core skill and is not at risk to be replaced in a short-term perspective. However, this thesis suggests that the development of an AGI may replace the manager based on that an AGI system has a higher analytical ability and would be able to set appropriate objectives and manage the project team better than a human manager. In such a scenario, the thesis suggests that the project manager should be augmented by the AGI, where both the manager and the AGI can be part of the decision-making process. For example, a key role for the manager may be to have the responsibility to ensure the AGI follows ethical and moral guidelines.

Appendix A Articles Included in SLR

Table 19: Final 63 articles included in SLR

	Conceptual papers
Publications	**Research Context and contribution**
(Chevallier and Russell, 1998)	A conceptual paper discussing the potential of AI and expert systems in project management and specifically construction projects and the theory behind automation of project schedules.
(Currie and Drabble, 1992)	Discussed the challenges and potential of using a DSS based on AI technique for cross-industry project planning and scheduling. Early published articles conduct a conceptual discussion on this topic.
(Klapka, 1994)	The paper discusses AI in project management from a conceptual perspective of mathematical modelling.
(Kumaraswamy et al., 2004)	The paper holds a conceptual discussion on the potential of using AI methods to improve collaborative decision-making with multiple stakeholders in construction projects.
(Li et al., 2021)	The findings suggest construction projects can benefit from an AI office gathering and analysing data. This can lead to improved stakeholder management.
(Nazarenko et al., 2022)	The authors suggest AI can be used for business road mapping by overcoming human bias and pre-assumptions during project planning.
(Niederman, 2021)	Contributions include 1) generally project managers need some AI knowledge, however, they do not need advanced AI skills, 2) project software will most likely become more advanced through AI and become more cost effective, and 3) managers working with AI cannot ignore to develop project management skills.
(Noronha and Sarma, 1991)	The paper discusses AI through project scheduling conceptually.
(Roth and Hendrickson, 1991)	The paper discussed the potential of using AI for automated explanatory capabilities in project management.
(Sarma, 1994)	The paper studies how AI can be used in project management by assisting with decision-making.
	Individual AI model papers
Publications	Research Context and contribution
(Aljaz, 2024)	The paper suggests ChatGPT has the potential to improve decision-making through theory of constraints.
(Al-subhi et al., 2021)	The paper studies the use of AI technique in project management through project evaluation.
(Amândio et al., 2021)	The paper studies how AI technique Genetic Algorithms can be used during project management of road construction for optimal allocation for heavy equipment.
(Badiru and Sieger, 1998)	The paper studies how AI technique neural network can be used for project management and predicting the performance of highly risky projects.
(Bahi et al., 2024)	The authors propose generative AI will have large implications to software development within e.g. role definition, requirement mgt., change resistance, and effort estimation.
(Greeshma & Edayadiyil, 2022)	The authors suggest applying image processing methods to monitor construction project progress, this can have significant implications on current manual methods.
(Heintz, 1991)	The paper studies AI through a conceptual framework to be used in in software project management.

(Jüngen and Kowalczyk, 1995)	The paper suggested a Decision Support System as a conceptual approach for project management planning and control in building and construction projects.
(Karnouskos, 2024)	The paper suggest generative AI models are able to answer PM certificate exam questions, managers and AI to be in partnerships, and PM certificates should include assessments how managers apply generative AI for project purposes.
(Kashiwagi and Byfield, 2002)	The paper studies the use of AI technique for project management procurement
(Lung and Wang, 2023)	The contribution includes optimised image recognition through neural networks.
(Novembri and Rossini, 2020)	The study embedded an AI model project management construction and BIM to reduce the design and planning errors.
(Nyqvist et al., 2024)	The paper evaluated the performance of generative AI for risk management. The authors suggest AI and managers to collaborate.
(Pan and Pan, 2011)	The paper studies how to optimise project management scheduling through an AI model.
(Strang and Vajjhala, 2023)	The authors suggest that project managers' experience and whether the manager is outsourced are the two most significant indicators of failure.
(Varouqa, 2021)	The paper studies how to use an AI model for construction projects.
(Viktor et al., 2021)	The paper studies an AI model to forecast start-up investment projects. (project initiation, start-up, investment)
(Wauters and Vanhoucke, 2014)	The paper studies how AI can be used to measure EVM metrics.
(Xu and Lin, 2016)	The paper studies how AI can be used for problem solving and decision-making.
(Zhou and Zou, 2021)	The paper studies how an AI model can assist in complex project decision-making.

Hybrid AI model papers

Publications	Research Context
(Chang and Liang, 2023)	An optimised AI risk evaluation model for agriculture projects.
(Cheng et al., 2009a)	The papers studies multiple AI models for predicting project costs in construction projects.
(Cheng et al., 2009b)	The paper studies a combination of AI models, used in this research where K-means, Genetic Algorithm, Fuzzy Logic and Neural Networks (NN). The method was used for prediction of project cash flow and it was suggested for project managers to use the model for cash flow control. Controlling cash flow can be translated to monitor and control phase.
(Choi et al., 2021)	The paper discusses how to optimise decision support systems through several AI models to improve project risk management in construction projects.
(Chou et al., 2014)	Chou et al. (2014) apply a hybrid AI model to predict when stakeholder disputes will occur. (predict stakeholder disputes)
(Darko et al., 2023)	Applied the model on green building projects to increase the probability of successful sustainability projects.
(González-Carrasco et al., 2012)	The use of AI models was studied for project management effort estimations. AI models included Neural Networks and Fuzzy Logic, for effort estimation in software projects is a common heuristic practice for project managers.
(Hajiali et al., 2020)	The paper studies project control through AI models to estimate EVM metrics. The authors used project data from previous projects and
(Kim and Jang, 2023)	The paper suggests project funding to be significant when classifying R&D project success.
(Ko and Cheng, 2007)	The paper uses a combination of AI models to improve project control and monitoring.

(Li et al., 2002)	The paper studies how project management knowledge management can be improved through combining AI models in a web-based project tools.
(Liu and Hao, 2021)	The paper studies how AI can improve project scheduling.
(Uddin et al., 2022)	The authors propose a data-driven framework for project management through AI models.
(Wauters and Vanhoucke, 2016)	The paper used a combination of AI models to predict final duration based on EVM metrics.
(Wauters and Vanhoucke, 2017)	The paper use a combination of AI to improve EVM metrics.
(Yaseen et al., 2020)	The paper studies how AI can be used for project risks in construction projects.
(Zheng et al., 2021)	The paper studies how AI can predict project stakeholder litigations. (predict stakeholder disputes).

Empirical papers	
Publications	**Research Context**
(Barcaui and Monat, 2023)	A comparative study between generative AI and project managers in project plan development.
(Bozorgzadeh and Umar, 2023)	Studies how computer vision impact construction projects.
(Cancer et al., 2023)	A survey studying what industries AI can support.
(Farrow, 2021)	The paper studies what AI should do and not in project management.
(Fridgeirsson et al., 2023)	A study based on how AI may affect PMI knowledge areas.
(Fridgeirsson et al., 2021)	The paper studied the future effect of AI on project management knowledge areas for the next ten years according to project managers.
(Holzmann et al., 2022)	The paper studies project managers' expectations of AI in project management.
(Kumar et al., 2021)	The paper studies whether AI is a potential success factor for project management construction.
(Mishra et al., 2023)	The paper discusses how AI can support IT PM.
(Pitt et al., 1996)	The paper discusses how AI can be used for collaborative project management to enhance collaboration between project organisations. (Finance, a system for brokers)
(Tominc et al., 2023)	Studies how agile PM can increase AI and project success.
(Tominc et al., 2024)	The paper study small and medium enterprises' use of AI for project management.
(Wachnik, 2022)	The paper studies how AI is used in project management in industry 4.0 projects.

Comparative papers	
Publications	**Research Context**
(Bakshi et al., 2016)	The paper studies how several AI techniques can improve project management technique of Earned Value Management.
(Chou et al., 2015)	The authors compared AI models to forecast the bidding award procurement when limited information is available in construction projects. (forecasting bidding contracts).
(Pradhan and Akinci, 2012)	The paper studied the use of an AI model to automate project planning approach for construction projects.

Appendix B Research Ethics Form: 53466

APPLICANT DETAILS

Applicant name:	**Fredrik Kockum**
Supervisor (if applicable):	**Dr Nicholas Dacre, Dr Serkan Ceylan**
Other researchers/collaborators (if applicable): ***Name, address, email, telephone***	Fredrik Kockum – Research Associate and PhD candidate, Dr Nicholas Dacre – PI and PhD supervisor, Dr Serkan Ceylan – Co-I and PhD supervisor

STUDY DETAILS

Title of study:	Artificial Intelligence in Project Management – How to leverage Big Data Knowledge Mitigation in Complex Projects
2.2 (M*) Type of study (*e.g. Undergraduate, Doctorate, Masters, Staff*):	PhD research and Research bid via the Association for Project Management
2.3 i) (M*) Proposed data collection start date:	01/12/2019
2.3 ii) (M*) Proposed data collection end date:	30/6/2022

2.4 (M*) What are the aims and objectives of this study?

Aim: The research aim is to study how project managers can leverage big data knowledge mitigation through elements of artificial intelligence in complex projects

Objectives: Investigate the use of artificial intelligence in complex projects. Evaluate the use of Big Data in complex projects. Establish how project managers can use artificial intelligence for big data knowledge mitigation through qualitative interviews and quantitative survey

2.5 (M*) Background to study (*a **brief** rationale for conducting the study. This involves providing a brief discussion of the past literature relevant to the project)*:

As part of the fourth industrial revolution, artificial Intelligence (AI) is argued to impact society on the same level as electricity once did. The discussion regarding AI has two main stands, one arguing AI will take jobs and become superior trough artificial general intelligence (AGI), and the second stand which state AI is should be embraced and embedded into future businesses.

AI is a young research field in social science perspective compared to its origin within computer systems, where the area first recognized by Pitts and McCulloch in 1943 (Russel and Norvig 2010). Awareness of AI systems' possibilities of solving problems is gaining attention. Wilson and Daughetry (2018) suggest the term collaborative intelligence to be used to describe the relationship between AI and humans, whereas Kolbjornsrud, Amico and Thomas (2016) suggest treating intelligent machines as colleagues. This is relevant to research objective number one, how AI can be used by project teams. The research will base its hypothesis upon the pragmatic view that AI has the potential to augment the project management profession.

As a growing profession, project management needs to stay up to date with new technologies of the fourth industrial revolution. The Project Management Institute (2017) predicts a potential GDP loss of 2.7 billion USD in the UK economy due to future shortage of project managers. Positioning the project profession as attractive for talented individuals to enter is therefore of significant importance on a national level.

2.6 (M*) Key research question (*Specify hypothesis if applicable*):

How can project managers leverage big data knowledge mitigation through elements of artificial intelligence in complex projects?

2.7 (M*) Study design (*Give a **brief** outline of basic study design*)

Outline what approach is being used, why certain methods have been chosen.

Qualitative interviews are conducted with project managers to collect empirical data, the interviews will be semi-structured.

SAMPLE AND SETTING

3.1 (M*) How are participants to be *approached*? *Give details of what you will do if recruitment is insufficient. If participants will be accessed through a third party (e.g. children accessed via a school, employees accessed via a specific organisation) state if you have permission to contact them and **upload any letters of agreement to your submission in ERGO or provide the name and contact details of the person granting you permission to access the sample (to check that permission has been granted)**.*

Participants will be approached through personal network and through events.

3.2 (M*) Who are the proposed sample and where are they from (e.g. fellow students, club members)? How many participants do you intend to recruit? *List inclusion/exclusion criteria if applicable. NB The University does not condone the use of 'blanket emails' for contacting potential participants (i.e. fellow staff and/or students). It is usually advised to ensure groups of students/staff have given prior permission to be contacted in this way, or to use of a third party to pass on these requests. This is because there is a potential to take advantage of the access to 'group emails' and the relationship with colleagues and subordinates; we therefore generally do not support this method of approach. If this is the only way to access a chosen cohort, a reasonable compromise is to obtain explicit approval from the Faculty Ethics Committee (FEC) and also from a senior member of the Faculty in case of complaint.*

The proposed sample group contains of academics and practitioners of the project management community. The two major industry organisations are the Association for Project Management and the Project Management Institute. These organisations have groups on LinkedIn which are open for all members of the public to contact. The proposed sample group is not limited to these organisations.

3.3 (M*) Describe the relationship between researcher and sample (*Describe any relationship e.g. teacher, friend, boss, clinician, etc.*)

The relationship between researcher and participant is neutral and professional. When interacting more often some of these relationships may turn into informal professional relationships.

3.4 (M*) Describe how you will ensure that fully informed consent is being given. *You must specify how participants will be told what to expect by participating in your research. For example, will participants be given a participant information sheet before being asked to provide their consent? **Upload copies of the participant information sheet and consent form to your submission in ERGO.***

Qualitative methods: Participants will be given or sent to via email a participant information sheet prior to signing consent form.

3.5 (M*) Describe the plans that you have for feeding back the findings of the study to participants. *You must specify how participants will be informed of your research questions and/or hypotheses. For example, will participants be given a debriefing form at the end of your study? **Upload a copy of the debriefing form to your submission in ERGO.***

Qualitative methods: A PIS will be shared and a consent form will be signed prior to the interview. A debriefing form will be given to the participant after completing the interview.

4. RESEARCH PROCEDURES, INTERVENTIONS AND MEASUREMENTS

4.1 (M*) Give a brief account of the procedure as experienced by the participant

*Make clear who does what, how many times and in what order. Make clear the role of all assistants and collaborators. Make clear total demands made on participants, including time and travel. You must also describe the content of your questionnaire/interview questions and EXPLICITLY state if you are using existing measures. If you are using existing measures, please provide the full academic reference as to where the measures can be found. **Upload any copies of questionnaires and interview schedules to your submission in ERGO**.*

The research associate will execute this research and have discussions with PI and Co-I.

Qualitative methods:

Interactions with participants will take place in order to build rapport, however the number of interactions will be limited to the respect of the participants' schedule and available time. The number of interactions is not general per se, the number of interactions between researcher and participants will be flexible and be determined in relation to the participants' schedule.

Participant's time spent on the interview will be approximately one hour effective time. No travel is needed for the participants. The research associate will travel to the participant if conducting a face to face interview. When travelling is not possible an interview will be conducted through a Skype call.

5. STUDY MANAGEMENT

5.1 (M*) State any potential for psychological or physical discomfort and/or distress?

There is no potential psychological or physical discomfort and/or distress in this research.

5.5 i) (M*) How will participant anonymity and/or data anonymity be maintained (if applicable)?

Two definitions of anonymity exist:

i) Unlinked anonymity **-** *Complete anonymity can only be promised if questionnaires or other requests for information are not targeted to, or received from, individuals using their name or address or any other identifiable characteristics. For example if questionnaires are sent out with no possible identifiers when returned, or if they are picked up by respondents in a public place, then anonymity can be claimed. Research methods using interviews cannot usually claim anonymity – unless using telephone interviews when participants dial in.*

ii) Linked anonymity **-** *Using this method, complete anonymity cannot be promised because participants can be identified; their data may be coded so that participants are not identified by researchers, but the information provided to participants should indicate that they could be linked to their data.*

Qualitative methods:

Linked anonymity will be provided for the participants of interviews. The data will be coded, however complete anonymity is not possible, any information revealing the identity of the participants will be coded. Interview subjects will be informed that their data can be linked to them until the researcher code the data.

5.5 ii) (M*) How will participant confidentiality be maintained (if applicable)?

Confidentiality is defined as the non-disclosure of research information except to another authorised person. Confidential information can be shared with those who are already party to it, and may also be disclosed where the person providing the information provides explicit consent.

Confidentiality will be maintained in discussions with supervisors by using coded data. If the procedure of coding the data is not sufficient for participant, the data will be removed from the data record

5.6 (M*) How will personal data and study results be stored securely during and after the study?
Researchers should be aware of, and compliant with, the Data Protection policy of the University (for more information see www.**southampton**.ac.uk/inf/dppolicy.pdf*). You must be able to demonstrate this in respect of handling, storage and retention of data (e.g. you must specify that personal identifiable data, such as consent forms, will be separate from other data and that the data will either be stored as an* ***encrypted file and/or stored in a locked filing cabinet****).*

Qualitative data: The data collected will be stored on encrypted files and only the research team will be able to access this. The data will be coded and once the interview has been analysed, the stored data will be in form of common key words and themes, no detailed information will be kept when the data analysis is completed. The data which is kept will be stored as encrypted files on a password access computer and a backup USB with password access.

Consent forms will be stored on a separate USB and separate encrypted files as the collected data.

5.7 (M*) Who will have access to these data?

Only the PhD candidate / research associate, PI and Co-I will have access to the data files.

Appendix C Interview Data

Table 20: Interview data summary

Participants	22
Words	101,900
Time recording	Approximately 25 hours

P1 January 2020

Interviewer: What is your current role?

Participant: Uhm so I am working as a consultant but also academic tutor. Have done this for several years and hope to continue doing this.

Interviewer: What is your project management experience?

Participant: I have been working in project management for nearly a decade or more in some way or another. Came into projects from a consultant role and had several different roles in XX. It's been a good journey, the profession has changed a lot since then and I hope it will change even more so that AI and the stuff we will talk about can make a difference.

Interviewer: Are you or have you been involved with a project management membership?

Participant: Yes I am involved with APM. [Association for Project Management]. Have been a member but not always, have also been updated with PMI [Project Management Institute]. They all do a good job but they can't cover it all I feel. They have had some challenges with adapting to new methods and they follow practice rather than leading it is my perspective.

Interviewer: What is your experience with Artificial Intelligence (AI)?

Participant: I have worked with AI in different forms. I've done some simple coding, but also at the work place in some ways by tracking and risk management. The data question has been around for ages, but no one really has done anything great yet I feel. They all talk about data and that data is the new oil etc. And um, it's true but also we need something more than that. We cannot only focus on the data, what happens next? The technology for analysing the data is needed now more than ever, I think we need to see more case studies and examples before people really understand why we need to focus on the data. I guess that wasn't your question but I think it is very relevant that the data is key for AI and I've seen good and bad examples. I

think we can do more with AI but it is difficult to scale it, we need to continue developing what we have and I hope to more of it.

Interviewer: How do you use AI in your current role?

Participant: I don't use AI in my current roles. But I have done it before.

Interviewer: How have you used AI previously? Have you used AI in projects?

Participant: Yes, it depends what we mean about AI and how we define it, but I have used AI or AI scheduling for tracking and risk management in the sense that we let the system analyse the schedule and gives us an output.

Interviewer: I understand, can you expand on this? How was this scheduling tool used?

Participant: Uhm yes well the AI scheduling traced the progress of the project and the AI highlighted when tasks were at risk to not be completed in time. We wanted to use it for more but couldn't every time.

Interviewer: Interesting, what other functions did the AI do?

Participant: It did lots of things. I don't remember them all, but for example it calculated resources and could run different analysis with costs and it was also looking into earned value management. I'm sure it could do more if we had the data, it can probably do more today.

Interviewer: Is this something you can call a decision support system? What did you call the system?

Participant: Well decision support systems is a very general term, so I guess you could call it that, but we just referred it to the IT system or the scheduling system. We didn't talk about it as a super AI system or anything like that. But it was based on a decision-tree and some machine learning if you've heard of that.

Interviewer: I understand thank you for clarifying that, I might return to that question later. First I would like to ask, how do you define project control?

Participant: Well it depends.. hmm, I think I would say it's when any activity needs monitoring. You can go one step further and say it's when you can measure any goals against the progress.

Interviewer: Based on your experience when would you say the controlling takes place?

Participant: Well I would say anytime really, in a large project, you will have to control all activities, maybe not in the early phases of the project but definitely after that. I think you are

after a project's life cycle which is talked about in project academia but its more complex than that in reality.

Interviewer: In what project phases do you use AI?

Participant: So when I've use AI, if we can call the scheduling tool for that, it has been used for monitoring the project schedule. So anytime when there was a schedule that needed control and monitoring the AI was analysing it.

Interviewer: If you do, how do you use AI for project control?

Participant: So I guess you can say that we used the AI tool for controlling of the schedule. The tool would indicate if the project was escalating based on some measures.

Interviewer: I understand, thank you for sharing that. Can you explain escalation? How do you define project escalation?

Participant: Escalation is quite simple I think. I would say that escalation is when the project need some extra care, so to say. Something is going wrong and you need to fix it.

Interviewer: Would you say escalation is when the project is escalated or when someone "escalates" the situation, if you understand what I mean? In the sense of an action

Participant: I think I understand, you mean is the escalation when the manager escalates the situation himself?

Interviewer: Yes exactly, or is it only the project that can escalate?

In our context I would say it is the project, but some might not agree with me, but I think something is escalating when it need more care or action against. Like when we are at war and conflicts between countries, the situation escalates and then the mediation takes place and so on…

Interviewer: Thank you, I understand what you mean. How do you react to project escalation?

Participant: Well sometimes its easy to know what to do about the issue, sometimes it's difficult knowing what should be done. Escalation is interesting and it is not always recognised, but it is through sunk cost. It happens to everyone in one way or another.

Interviewer: Can you explain sunk cost for me please?

Yes sure, have you heard about it?

Interviewer: I have yes, I have but not in detail I think, and the language barrier I am not sure what it means. If you don't mind explaining.

Participant: Yeah sure, it's when someone throws good money on bad money, in simple terms at least. A very common thing in projects is when management is too invested and blinded by finishing the project and they don't want to see how bad it goes and they think that if the problems are discovered the project will be stopped and the all the money and time invested will be lost etc and the reputation of the project manager is on the line. It is a common thing, I mean a failed project can affect a manager's career. I think Khaneman has talked bout this, you should look him up.

Interviewer: Thank you for clarifying. Can you explain how this concept affects you? Do you have an example?

Participant: Well I don't really know it there is a clear example. There are many projects that have gone wrong but I don't know if there is an example where I was involved during a sunk cost scenario. Or do you mean in a project?

Interviewer: Yes if you have any example in general how you act when sunk cost is happening?

Participant: Well I am in denial I guess. I can't see the forest for the trees and is blinded to success on the project plan. It's complex and if I would see it I it would be easy.

Interviewer: I understand, have this happened when you used the AI scheduling tool?

Participant: Yeah, I am not with that company any longer I must add, so it may have changed or they may not even use it anymore. But it happened sure, it will happened in every project I think. The system was used by the team and highlighted when the schedule was at risk based on certain measures. And it gave a warning message when a risk was identified.

Interviewer: Ah interesting, how would you and the team act on this message?

Participant: We had to identify what needed to be done, the AI was not advanced enough to give us any solution to the problem. They were always working on improving it but it didn't give us the answer only told us when it was something wrong.

Interviewer: I see thank you for clarifying that. Was this activity easy? I mean identify what needed to be done?

Participant: No, usually no, never is these days. Sometimes it could be done by just moving resources [team members] around, but usually not easy to know what was the best option. It needed to go through a process of error analysis with the team or department.

Interviewer: Thank you. How about data? You talked about it before. The saying "garbage in, garbage out". Was this a challenge for you?

Participant: There is a major data challenge for project management and many industries to be honest. You can't do anything with out data. Doesn't matter if you have the best AI and newest algorithm if you have poor/shit data management.

Interviewer: What is your experience of data management in projects?

Participant: I don't have much data knowledge, I am not a data scientist that I know the technical details. I can say that I know the importance and I have seen when it goes wrong. But I haven't been in roles where it's my role to clean and manage data formats and sources.

Interviewer: I understand, thank you clarifying. How would you say the future of AI and project management is developing?

Participant: There are huge challenges, also great things that can be done. We focus too much on unique project characteristics of Project uniqueness. There are more things in common between projects than we project professionals typically think. Data here is key to synchronising in organisations between projects but also perhaps between organisations. It is almost impossible today. GDPR is one thing and other data regulations make it almost too much of work to just understand it. There are not enough resources as there is.

Interviewer: Interesting thoughts. Do you have an example when this has happened, when data has been shared successfully?

Participant: Well, yes and no. I guess mergers have made it possible for organisations to use historical data, but it's not the same. But again I am not the data analyst so I don't know the details.

Interviewer: I see. What other opportunities do you see with AI and project management?

Participant: Well I see it opens roles which we have not seen before. Look at yourself, your PhD can be something useful. We need more PhDs studying this, more development of algorithms is one thing. Understand where we can apply the AI is another thing. I don't think we know today the full potential of it. There are probably areas we haven't thought of.

Interviewer: What can you see short term that AI can benefit?

Participant: I believe improving scheduling control. Resource allocation, scheduling in general, data analysis, finding relationships we are not capable of in the data, probably also prioritising and improving efficiency, and of course automation. Those are some of the benefits. It comes with risks, some role may be replaced. Project entry roles will struggle to compete with AI.

Interviewer: Do you see any risk for higher roles to be replaced

Participant: Well you asked for a short term perspective, and for a short term no.

Interviewer: How about in a longer perspective?

Participant: In a longer perspective probably yes. But we honestly don't know. I think who ever states X, Y and Z, and the Armageddon of AI may be saying a bit too much. But if AI gets anything like general intelligence, then the project manager is definitely at risk.

Interviewer: Interesting thank you. I think I will refer back to the sunk cost and the use of the AI scheduling tool you mentioned. Do you have other examples of scenarios and decisions that can occur in projects or when using AI?

Participant: I am not sure what you mean, I mean there are plenty of decision-theory related to project managers and their decision and behaviour. In research there are several examples in heuristics and biases for example. This is not what I have learned form projects but from academia.

Interviewer: Ah very interesting. Do you see any of these concepts in the projects you have been in?

Participant: Well decision-theory is always active and usually decisions are done under uncertainty and risks. You can read more about this. Heuristics is always active in all our decisions. It is essentially when we make decision we don't spend too much time and effort on the decision.

Interviewer: Ah okay, interesting, I will read more on this topic. So it is still early in my PhD research. Is there anything you want to add to this conversation?

Participant: `Not really, hope your PhD goes well. I hope some of the things I said made sense and was of any help.

Interviewer: Thank you. You have been very helpful. Thank you for taking your time.

P2 February 2020

Interviewer: Can you introduce yourself and your role in your organisation?

Participant: My role here is project controller, I work within what we call "sub-systems". The sub-system where I work is control and within software. Previously I have had project management role and software engineer and progressed from there. Also with the NHS as a PMO role.

Interviewer: What is your experience of project management?

Participant: I've been in different roles within software, like developer in a team but also project manager or project lead as you may call it. Hmm, I guess you can say I have always been in projects, as a software developer I always work project based.

Interviewer: Are you a member of the APM or the PMI or similar industry organisations?

Participant: I am an associate of APM. And I have taken courses in agile project management for the purpose of leading the team.

Interviewer: Can you tell me about your experience of AI?

Participant: I came in contact with the concept of AI when I did my post graduate degree. I worked with expert systems, teaching a machine to classify certain objects. Since then I have not done much AI related, up until recently. I started to look into the applications of AI in project management. We have good systems in place and these systems can be adopted to use AI techniques or we can develop AI techniques to enhance those systems. In my organisation we are going through a lot of change within project management processes and I can now start seeing where we can inject AI to work more efficiently and to develop cost effective systems and elevate our performance. All of those things AI can assist with. "I think that is where the cost benefits for all organisation sit, to improve the performance, efficiency and the way projects are delivered". I have found very little in terms of AI being used within project management, however, what I did find was an interest for development, which is a good starting point. That gave me an incentive to share my ideas with my senior management. We seem to be at the same starting point, there are only a handful organisations using AI at a process level today.

Interviewer: How do you use AI in your current role?

Participant: Well it's [AI] under development at the moment, but we are making progress. It's used for analysis of the project and the end goal is for it to assist, or augment if you want, the

teams. You can say I use it for specific analytical purposes, and it gives me an assurance of knowing if there is something I am missing outside my control.

Interviewer: Ah, interesting, can you please expand on the analysis the AI does and the assuring part?

Participant: Yes absolutely, hmm, you mean the AI analysis and what it does? [Yes, nodding] Well, it works inside a project planning tool, and we have put it on steroids if you understand the reference [joking]. It cannot do everything for us but it helps us plan and estimate the schedule. And it assures us that everything is okay until it notifies me that something isn't. I I then need to see what's going on. It is not always right, but it usually brings in a perspective or we have missed something.

Interviewer: You said that you brought this idea to senior management. When you approached your senior management with this proposal to look into AI, what reaction did you get?

Participant: I was impressed, there was a little scepticism, but AI was seen as an area only in robotics. That is only one form of AI. I went through the concepts of explaining AI, e.g. expert systems and classification systems. I started to explain that we can teach machines to learn from our project data. I explained that we can use historical data to teach machines to think about project management in mathematical way, a lot of the algorithms behind AI are mathematical and predict from historical data. It not about robotics anymore, we can use this for what we are doing through algorithms. I did programming during university and back then it was very different of course. We didn't have the computer power and IT infrastructure to apply the technology but now we are starting to see this in some examples. We will see more of this in the future of course but we can do something now. And the funny part was that the senior management agreed with me. It wasn't just like talking to a wall and nothing more happened. They took it in and they thought it sounded like an interesting idea. And not we are doing it.

Interviewer: Very interesting, what was the first thing you had to do then? Can you explain the process of how you managed to get to where you are now?

Participant: Mhm yes sure, you mean about the IT tool?

Yes exactly.

Participant: Well we had to start with the data, it had to be in order before we started to feed it into an algorithm. We had some analytical skills inhouse that we gathered and made a plan that within X months we need to have this tool. Then it was a major work to do before we got where we needed with the data. It just was of right quality or format. We decided to start small with a

specific are, I can't tell you what area I think… My senior management doesn't want me to share details, they are very careful.

Interviewer: Do you see any low-hanging fruit within some project areas? Like goal setting, Project Planning, Project Scheduling or Project Control?

Participant: I see massive opportunities, differently in these areas. I see data as "what you put is what you get out." "Garbage in and garbage out." For AI to work, data has to be standardised and structured in order for it to be of any use. If an organisation is using unstandardized data it will not work. That means the organisation has to develop a certain standard and the cost of structuring that data has to be considered. If an organisation is working on a portfolio, program and project level, data is created within those niched levels. As each niched level and area of a large organisation is creating data by itself, it requires a lot change in processes to standardise those processes to create the structured data which is necessary, and this change is very costly. The backend data has to be cleansed and readable. There is an upfront cost to that.

Interviewer: Have you seen progress in your internal processes?

Participant: We are not using AI at the moment on a large scale. A lot of our systems are able to integrate with AI. At the moment it is about spreading the awareness. One way of absorbing the cost, we are at an early stage, we can start this change process now. We can look at the historical data and structure it. What are the key entities we need to put together or what is the key data types we need to have in mind in developing the AI system? I.e we got the historical data, what can we extract from that data that would benefit us going forward? We then have data that is being cleansed continuously as we are developing our processes.

Interviewer: Do you think you have the knowledge to begin that process? Or is that also a continuous process?

Participant: That is continuous. I suffer from "I don't really know how much I know". When I come across information I think "Okay I understand that". As far as my own skills of concern, I think I can be instrumental when looking at what data is needed in terms of standardised in terms of machine learning. That is the key point, trying to understand what data we need for the machine learning to take place.

I studied AI at an early stage. By then AI was coming "alive" again. AI has gone through different phases and I do have an advantage of having contact with AI during previous AI-winters. During that time, it was no talk about how AI can be used in PM, it was only talk about classification systems and neural networks.

Interviewer: You mentioned before that you use the AI for scheduling activites, in what phase in the project is this happening? Can you expand on this please?

Participant: Hmm um, I mean it happens as soon as we have a schedule. So it happens during the project all way through. From the planning phase we have a schedule for the planning itself, and then the project is executed we have other controlling measures and goals.

Interviewer: Can you expand on these controlling measures, how would you define project control?

Participant: You always need to control the project is going well and that it is not going the wrong way, it is challenging in the beginning since you may not have a clear goal yet. It becomes easier, in theory at least, to identify when something goes wrong later in the project. Sorry, what was the question again?

Interviewer: Yes, no problem, how would you define project control?

Participant: Ah okay, well anytime you need to control the time, cost and any other set measures. Either look at each individual task or look at the overall phase.

Interviewer: I understand thank you. Can you explain how your projects create data today?

Participant: For project scheduling, we use a special program, we collect data about milestones, scheduling, costs, budgets and resource management data. All of those areas can be integrated with AI. If you are able to teach an AI system to estimate costs, then then you have a system that can assist you in that process. If you can integrate milestones adherence in an AI system, the machine can understand the trajectory of the project and it can learn the critical path. It may then communicate alerts and other messages if you don't do x, y and z.

Interviewer: If you say the AI system can learn the critical path form previous projects, how similar are your previous project compared to your new projects?

Participant: The initial process is that we build one type product with several components. When the product goes into service, we look at developing modifications, there are different variations in those projects and how those projects are delivered. I don't see one machine understanding one specific project, we do portfolios, I see multiple machines at multiple levels understanding various different projects and delivering trajectories. In our organisation on a portfolio level, a specific data analyses will take place and at sub-system level there may be machines looking at different elements within those areas. Predicting analysis will take place on sub-system level. With that said it is challenging when we do have very specific projects.

Sometimes we have to remove some projects from out data base cus it is too unique. But it doesn't happen too often.

Interviewer: I would like to go back to these messages you get from the system. How do you act when you get one of these?

Participant: We have a solid escalation process. Everyone has the authority to escalate a task or anything, even the system. We act on it the same way as every other escalation. What is the root cause? Why is it happening? Do we have to do something about it right now or can we wait and see if the conditions changes?

Interviewer: You say have a solid process for escalation. Does it look the same for a team member and if the system bring up an escalation?

Participant: In theory yes. You ask the member what is the escalation based on? What data? You do the same with the system. And then ask follow up questions to find the root cause with the team member. The systems needs more scrutiny by looking at what data is used for the analysis and is this escalation relevant based on the circumstances. Is there something the system is not including in the analysis? And if so it needs to or we need to consider that the system might not have the entire picture in this case.

Interviewer: Very interesting. You mentioned before about how data is created in your projects. Is there anything there would like to add regarding that the system "may not have the whole picture" as you put it?

Participant: Well yes and no, I mean we could feed the system with all data we have but it would take too much time and I'm not sure if we have the IT power for this. It would take too much resources. It is a question of IT infrastructure if we want to have all the data in this system.

Interviewer: I understand, are you considering investing and make your infrastructure better?

Participant: We always do but sometimes it is not possible, we have our priorities. I mean I am just glad we have come this far. If the system performs well and we can show something from this we will likely have more funds to develop it further later on. It all depends on how it goes and how the management sees on this area. It is challenging to get the resources and funds. We compete with all kinds of initiatives like green initiative to reduce our CO2 for example. If there is another AI spring, which we may be entering now we may get more funds and be staffed up. Now we have to do with what we have.

Interviewer: Thank you for your answers so far. I just need to look at my questions here.

Participant: No problem, I will have another coffee then haha [laughing].

Interviewer: I would like to ask more about project escalation.

Shoot, go for it.

Interviewer: Who is the final decision-maker deciding if there will be a mitigation action or such thing? Is the AI system involved in this?

Participant: Well no, all the decision-making is made by us and the teams. The system is only there for assistance, it is not predictive in the sense that is recommends us what to do. We want to get there but we are not yet. So it's the PM who decides and depending on the scale of the escalation it can be done by the internal team or it needs to go up to another management level like the sponsor level.

Interviewer: Can you expand on the responsibility, who is responsible if something goes wrong? For example is it the project manager, the system, the data or even the data scientist responsible for the data?

Participant: Hmm interesting question, I must say though that we don't play the blame game in my opinion. It is very rarely that someone specific gets the blame. But the responsibility is always on the project manager that the project is on time and budget. Bad things will happen of course and you cannot control everything but I think that the PM has most responsibility. The system can't be held responsible due to the passive role it is in fact not a person. We can instead improve it but it is in the end the project manager. This is the official stand. Then of course things can take different turns and people may be blamed behind their back like in every organisations there are politics and dynamics you cannot control or ever see with your eyes. I stay out of those discussions, I just mean there is the official responsibility and then there will always be people accusing others for being wrong etc.

Interviewer: You mentioned that it is the project manager who decides regarding the escalation and who has the final responsibility. I have a very exploratory question based on my research with is very much in discovery phase if I may say so. Still early in my PhD. So I would like to ask what is your experience on decision-making in project management? Is it something you work towards improving in your organisation?

Participant: Hmm, not sure in what ways you are expecting me to answer.

Interviewer: You can answer very freely, more simply, what is your experience and take on decision-making in project management?

Participant: There is a lot to unpick there haha [laughing]. There are so many different layers on decision-making and what makes an organisation efficient and how can we make the best decisions and how do we know we are making the best decisions? Many stakeholders too and different levels of authority

If you only focus on the project manager, how would you answer the question then?

Participant: Well then it's more personal I guess haha [lauging]. Still it's very complex, and it depends on the experience. You get better at making decisions and following your intuition when you are experienced in the area. It doesn't get easy even after that but you know then the complexity of the decision-process and the network of initiatives that is affecting your decision etc. This was an interesting question. I didn't expect to talk about this, it feels quite philosophical. Is this part of your research and the PhD?

Interviewer: Thank you for sharing this. I understand it can be unexpected to answer such questions. My research is still finding its way and part of the research method is to iteratively analyse the interview data the literature. I am asking questions based on my semi-structured method which allows to discover new themes and therefore I ask question which are not always prepared in advance. I appreciate your patience. I just need to look at my notes and questions here for a minute, sorry.

No problem, take your time.

Interviewer: Do you have anything to add on project managers' decision-making?

Participant: I don't know what that could be. Just that is very complex and the PM gets much shit [negative critique] although it is not always his or her fault. It is often out of the hands of the PM but still they get all the blame. Okay not always out of their hands, I have seen poor project management as well, but I think you know what I mean. I mean that it is even if you make every decision correct, there may still be problems and the project may not work out the way you hoped for. It's like in sports or any other references where there are external factors affecting your performance, you can do you best but it your opponent is better than you you will still loose. If you understand my analogy.

Interviewer: Yes I get you point, that's an interesting comparison, comparing projects and sports. I am myself a sports fan. I see your comparison in football for example, the manager will be fired if the team doesn't perform as expected but the players may be the ones who didn't do well enough or the opponent team was too good or so on.

Participant: Yes I'm glad you picked that up.

Interviewer: I appreciate you expanding your thoughts on that topic. I would like to go back to some questions about AI if that's okay. Would you say that AI can replace some of the project roles you have now in the organisation?

Participant: When I mentioned resource management I talked about engineers. An AI system can look at the skills and the capacity of those engineers and the capacity load for that project and that project task. It can then evaluate that and make effective planning. Talking about the roles that might be lost if an AI system exists, I think you still need human input and you can not develop an AI system and then be left alone. You would have to continuous feed more knowledge to that system, you are constantly developing algorithms as the environment changes.

Interviewer: How many are you today who is using the AI system?

Participant: It depends but it is usually around 3-4 or up to 10 or even more depending on the project.

Interviewer: Can anyone use the AI tool?

Participant: I would say so, it depends on your project role I would say. That is the most important part, other than that you can learn from someone else what the AI analysis or notifications tell you. And the persons who are on the team are not alone, there are always some people around that you can bring into the team to understand the AI for you. For now we have quite easy algorithms, not much back box there. Some say this is good some say its not good enough. We get the analysis and we act on what we have at the moment. But sure we would like to say that we have the best machine learning algorithm and it can do this or that cus it's sexy I guess. AI is such a buzzword. But we are at the moment okay with what we have. I mean it takes resources to make a ML model and then you are not able to understand eve. I mean what is the point then? We are working with people and AI, we are not making AI for chess or GO where we just have to watch and lean back. We actually have to understand what we are doing. Sorry did I go off track here perhaps haha [laughs]. Sorry I get a bit round up on this topic since AI is sometimes made up like a USP just for selling, and that's not where we should go.

Interviewer: Haha no not all. It was very interesting to hear your thoughts on this topic. I am aware of the black box challenge. Is this something you are interested in looking into? What are the challenges in this area?

Participant: Well I just don't see the point of making something super advanced and then when the user is interpreting the AI it doesn't know what it is based on. I think the challenges are

massive. If you have a machine learning tool then the data scientist on the team cannot even tell you what the output is based on. Imagine myself than as a project manager go and tell the sponsor that we have do something about the project

Interviewer: Is your staff able to automate their project tasks today and be in a monitoring role?

Participant: They can automate some of their tasks. We operate in a safety critical environment and I think you will always need a level of human judgement within that environment. They would be in a facilitating role rather than a monitoring role. They would facilitate the AI system and then to use their own judgement. If an AI system makes x, y and z predictions, you still need a human to understand the impact of those predications.

We need to move away from people thinking machines is going to run our lives. In my view that is not what is going to happen. It has to be first class data. I am going back to the data, the data that goes into project planning has to be clear, cleansed and structured data. E.g. Monte Carlo, if you would feed AI algorithms into that kind of tool, it would be a lot more efficient. Small baby steps is needed to incorporate AI into project management. If we are saying "Are we as a society familiar with AI? I think we are. We have voice recognition, although that might be difficult to use in an office place".

Interviewer: What are your thoughts in complex projects and do you think AI can be used for complex projects?

Participant: AI will change the way organisations diagnose risks and project tasks. For example, one product was found to have malfunctions and we went though an iterative process trying to find where the problem was. If we would have an AI system within a diagnosis activity, that would have improved that process.

Interviewer: Would AI be able to diagnose "unknown-unknown"?

Participant: Our organisation is using AI that will search data bases for information, this information which is search for is "unknown".

Interviewer: Thank you for sharing that. Let me check my notes and questions… So I am very happy you had the time to talk to me today. I appreciate your time. I don't have any further questions at the moment. D you have anything to add to our conversation?

Ah okay, it was much a lot of funk talking about this. I don't have anything to add.

P3 February 2020

Interviewer: Can you explain your experience in project management?

Yes of course, I found myself in a project manager role more than 15 years ago. Found myself in a project manager role rather than chosen it myself. Moved into programme management and change, eventually business transformation and then PMO. I am now a PMO specialist. Currently the Director of consultancy services at a consultancy firm.

Interviewer: Can you explain your current role?

It depends on the project, but I am a consultant mostly working in IT. Different projects related to what the client needs and their specific project.

Interviewer: I understand thank you. What is your experience of AI?

Participant: From a project management perspective, I have used AI for projects as a risk management tool. My whole thing around AI is that it can save time and resources but there are some things that need the human touch, certainly in our industry. It is easy to automate, automate, automate and loose that human element.

Interviewer: Are you using an AI today?

Participant: We talk about AI we work with AI models as well as Power BI which got some elements of machine learning and AI. Where you can take data and it can create smart reports and it can create insights on the fly. And that is really changing the game form a project management perspective. We spend time developing reports, collecting information, putting into fancy spreadsheets, turning it into graphs and then into power points. Where as Power BI and “tablo” non Microsoft, is really enabling people who are doing that manually, making sure that they focus on the output of the data. And focus on what does this tell us? How does that tell us a story? What is the insight we can win from that and what should we do as a business? There is incredible powerful stuff we are now starting to see. Certainly we are doing a lot work in that space and trying to make sure we learn with it, we evolve with it. Whether you like it or not it is the future.

Interviewer: Do you see any low hanging fruit AI can be used in?

Participant: I think the really low hanging fruit is in a lot of the very standardised reports. Organisations might say say “we do this differently to everybody else”, the reality is they do it pretty much the same as everybody else. Two big things, visibility across everything, if you are using the systems and the information and putting it on the same place you immediately get a level of organisations have never had before. So visibility is immediate win when you put AI into

an organisation. And the second is the standardisation, with Big Data and AI you are building reports that you then manipulate. “I just write the report I want to show”, because it is all about data. Actually the report that comes out is not generated by opinion, it is not someone’s attachment to the project. We get that standardisation we have not had before. From a senior team perspective, we can compare apples and apples. Taking away that human emotional element but being careful to consider that. Those two are the lowest hanging fruit in my opinion. As soon as you start using this new technology, you immediately get that win.

Interviewer: Referring back to AI model you mentioned before, were you able to experience a human element in this model?

Participant: I think it felt like a standard AI model when you used it even if it it also had a chat bot connected to it, but it was in its infancy. Is it ever going to be able to have a conversation with me? I don’t think so, which is why a lot of the time they tend to route you to a human. Because as humans we inherently need that connection, especially if we are asking for help, if I am on a worksite and I am asking for help I want somebody emphasise and I think that is where the human element will still be there. There needs to be route to a human, if 90% of the questions can be answered by a bot that is great but there needs to be something else that allows people to have that human interaction. Otherwise we will just be in the Terminator films.

Interviewer: Can you explain your current role and how do you use AI?

Participant: We are in the technology space, so we have to adapt. We are employing this technology for our clients, our clients want efficiency. They want to understand how this can help them. What we tend to find is that we can automate quite a lot reporting, the “ones” and “zero” stuff and what we are asking them to do is not to reduce head counts. I think that is a common misconception, that “the robots will take our jobs and that’s it”, but actually they are applying those people to do some more valuable stuff, so supporting, mentoring and coaching and making sure that we are innovating as an organisation. It is kind of giving our clients the chance to redistribute people to do real valuable work and focus on analysing the data rather than collating the data and that is the biggest difference. So what I do is I interpret the analysis with the help of the analytics team and decide whether the AI risk analysis is something we should act on.

Interviewer: Interesting, can you expand on the AI analysis. When do you use the model?

Participant: We use when ever we need it, if that is what you mean. There are no conditions in that way. We are free to use it however we want cus we do in the end own it ourselves.

Interviewer: I understand okay, can you specify in what phase of the project and for what activities the AI is used for?

Participant: We don't pin it down to a single phase or time in the project. We use it when we have the data. We come in to the client with this tool and we use when we have the data to use it. IT can be anytime from the beginning all the way through or at the end depending on when we come in.

Interviewer: I see, you may have touched on it before, can you specify and explain again what the analysis is actually based on? For example is it the schedule or the cost or resources etc?

Participant: Ah yes, okay well then again it depends on the data but we have used it for cost efficiency and risk assessments with multiple data sources. It can be resource management but I wouldn't say that is standardised for us, we have adapted our models before but it takes time and is not preferable and difficult to sell to new clients.

Interviewer: Is it possible to suggest that the analysis is part of a control process where you analyse the progress of the project?

Participant: I guess that is not far from what we do, it depends on what terminology we want to use. Risk assessment is used from our side sometimes or just optimise efficiency through X, Y and Z.

Interviewer: In what frequency are you reporting project risks?

Participant: We wish we could report in a "live format" which would increase our reporting frequency. This would mean we would have more relevant information. Now we have to settle with reporting as project goes on [project progress] and as close to "live" as possible, at least then we know we do the best we can and can train the AI model with newest data [project data generation] and trust the model [trust in AI model]. Unfortunately this leads to the AI is not always fed with the newest data and delays [project overruns], and it affects its output [misaligned goals and objectives]. If I trust the AI model [trust in AI model] and it recommends me to look at something, then I will be willing to follow its suggestion [willingness to take corrective action].

Interviewer: Is this time specific in the project?

Participant: This [willingness to take corrective action] has a strong influence on the final decision [strong feedback], and it can take a long time [long term delay]. A long time to change it.

Interviewer: Can you explain how you work with data validation in the AI model and the AI output?

Participant: The best practice is a key enabler for that, we know what kind of information we need. E.g. a portfolio dashboard. It is fairly standard and that it brings value as long as it tells a story. With project status reports, most people know what needs to be included, so best practice informs us for that reason. After that we have to look what makes the organisation tick, what is important for that organisation and how to we build that into collecting the right data to able to tell those stories. For example, if I work for a food manufacturer, their needs in terms of understanding insights are all around quality and traceability of their product. If I work for an energy company, then I sustainability and health and safety are fundamental to what they do. If I go to a fire service, they care about putting fire trucks on the road and keeping people safe. The first has to be grounded in best practice and 80% of the stuff clients are asking for from a reporting and data perspective is the same in reality. It is that 20% that makes them unique. It is that bit we need to grab hold of, an understand if we can we hold that information as data or is that something that requite human element.

Essentially I don't have much use of an AI if I don't have the data to feed it [the AI] with. And I need the relevant data, big data and other data terms make it sound easy to use data, but I can only take advantage of relevant data from earlier in the project or from projects I have worked on before which I know. The unique traits of a project make me believe that the project plan is solid [confidence in original project plan], because there won't be many other projects that we can reuse data or previous projects to learn from [project uniqueness perception].

Interesting: Can you expand on this perception of uniqueness?

Participant: Sure. I see myself and others have a tendency to believe the project we are working on is special, it's our little baby [project uniqueness perception], and is sometimes used as an argument not to trust the AI performance [trust in AI model].

Interviewer: Those 80% you mention; how do you work with that and what do you base that on?

Participant: It is a number based on my experience, I don't think I can quantify it but if I think about the clients I have worked with over the years, the reality as a consultant and within an hour I kind of know what they need. But I cannot go into solution mode because I have to learn what that 20% difference is to the client. When we deploy Microsoft technologies, companies think they are completely unique to everybody else and they are really the same as everybody else. I tend to say to clients to are all on the same journey, it is just a different flavour of it.

Interviewer: Thank you, now I will ask about the change process and implementation. Can you explain the change process and implementation of AI different stages of this digital change process?

Participant: With the technology we use, the first step is hard. Our clients need to be in a Microsoft space already. That is our only constraint, following that we can help anybody. As a consultancy firm the proud ourself on being able to start with you right at the strategy stage so even if you don't know anything about PM we can help you develop a strategy do make PM a discipline, we can support the standards and methods and the technology and the training and the innovation afterwards. For those who are the first adopters, it is then about gaining efficiency and innovation to keep the ahead of the curve, and we can do that.

For this question I will refer to the previous mentioned project management areas of Objective Setting, Project Planning, Project Scheduling and Project Control.

Interviewer: Do you see AI being implemented in Objective Setting?

Participant: We have been testing the intelligence behind historical data. If we start to build a strategy in order to grow our business by X amount, the AI has this stuff in the background it can suggest "are you sure that is the right percentage, because previous years you have grown Z%". I have already seen that working, we have not deployed it anywhere it is quite a new thing. That dynamic with strategy setting is starting to come out and I think that is where it will be helpful, where senior teams can go away ad do their blue sky thinking and having these crazy ideas and having that sanity check that says "based on historical information, not my opinion, is this the right thing to do? I think in term of objective setting that is a really good way where AI can help, it is to help them making an informed decision on where they are trying to take their business.

Interviewer: Thank you. Do you see AI being implemented in Project Planning?

Participant: We have the technology, we put in a task when planning a particular project. It can say "normally this takes for everybody else 3 weeks is this fine? Yes I'm fine. That dynamic scheduling already exists, again, using the historical data. At project planning stage, we are so early on, starting from the very beginning, we need stuff that does not force us to use a blanc piece of paper, that is dangerous. Because then it is just "finger in the air planning" and that is going to fail. So using the AI, allows us to see and interact with that historical data whilst we are planning using the lessons learned, it may say "the last five times we have had problems with that supplier, are you sure you want to use them?" That is where I see AI being used to help people to plan better using real estimation methods instead of "finger in the air". The other one is around resourcing and that will probably come into the next one which could be scheduling.

Interviewer: That falls into my follow up question, about project scheduling, can you continue talking about this area please?

Participant: Looking at resourcing, we do annual research. The top three most difficult processes for organisations to embed properly is resource management. Resource management is fundamental to us being able to do project management. We need to know where our people are, can they do what we have asked them to do? If they are having problem, we need to flag that and that is where AI is starting to get clever, we are already seeing it within forecasting. But rather, taking it to a deeper level, so that we are able to match people with skillsets. Will this task actually be able to be finished by the people based on all their activities. This really enables to find that balance for people so that they are not constantly run ragged. We know this is difficult, it doesn't matter who you speak to in the industry, resource management is one of the biggest challenges everyone faces. I con only think AI can help with that. That is an area where human we have not been able to nail it. So there has to be something else.

Interviewer: Can you explain your thoughts on if humans have not been able to do a better job with resource management. How will humans be able to manage the data for an AI application in resource management?

Participant: Because the paper written by Bent Flyvjberg, he talks about planning fallacy. We are all subject to bias and strategic misinterpretation. When we purposely inflate what we are able to to in order to get any external decision through and other are optimism bias. As human we tend to believe we are able to do more than we are capable of. If you say "Can you do that? Yes of course it will be done in two weeks." That might not be the reality. I think using AI is going to take that history, that this procurement that you are putting for 2 weeks actually always takes three months. It is not going to take the human approach saying "yea but I will squinch it in and I know the right people".

Interviewer: Regarding project control, how do you decide if it is the project plan or the project execution that is wrong?

Participant: I think there has to be some tolerances agreed on. Quite often what I found is "well if the project is three weeks late than it is red". Let's then take a step back, how long is the project? If it is a long-term project, it may not need to be placed as red. If it is a short-term project then yes it should be flagged as red. It is about putting the proper tolerances, not just a one figure that turns everything because it is not effective. First step is to get real tolerances, look at the length of the project and then decide the tolerances given the nature of the project. Put some science behind the tolerances we have. I try communicate that when we have high complexity in projects and that it can lead to future changes [to the project plan]. If the data is

there (the way we control the project) the reports will be automated for the most parts. This way we don't get hooked on previous estimations. The other thing we do is we add the ability for a human to add their opinion. This way the project manager can go in and flag something red even if it is green according to the AI.

Then we look at the benefit profile, where I think AI can help. What happens after the project? The second most problematic area for organisations to embed is benefits realisation, after resource management, this is based on our research. Actually being able to add everything up can connect all the dots, from an objective setting "have we planned it to achieve the objectives realistically?" and have we scheduled it right? Through to the connection of the dots from month to month so that we can see things coming rather than everything goes red without anyone knowing why. And then connecting the dots at the end, have we delivered the objective? There is no point of setting a smart objective if we can't prove that we have delivered it.

For me "it is about connecting the dots with the technology so that we are able to put in our opinion". In a previous position we used to give the project managers the ability override the automatic status but they had to justify it.

Interviewer: Interesting what you say about tolerances, but first I'd like to ask another follow up question. This sounds like it has to do with AI explainability, can you explain how you think about interpretable AI models and AI explainability?

Participant: Yes this is an interesting area, we must have some level of understanding why the model acts or makes a certain output. If we don't have a model I understand it is very difficult to justify our reasoning. If we use a machine learning model we are probably going to get very good analysis, but unfortunately we won't be able to understand why or on what premise the AI suggests its analysis because the understanding [AI explainability] of the model is low. Instead we can use a less advanced AI but will understand it instead, sometimes there are benefits of using one or the other, if I can understand it I will also trust it [trust in AI model].

Interviewer: How deep technical skills about AI do you think is necessary for your team and other project managers to interpret AI models or in this case your AI?

Participant: I think it depends on the organisation. Project management module are very different depending on the organisation. The need to be a bit of both. Project mangers need to understand why the computer says no and be able to say I don't agree and this is the reason why. And they need to do that confidentially. They need to have that awareness. I would not want the project managers to be so embedded in systems so that they are not delivering projects very effectively. Whereas the PMO they do need to have a bit more deep understanding, simply they are supporting other people who are using it. When the PMO receives a question

they will then hopefully know a little bit more than the project manager. The PMO are the ones who are doing the analysis and driving the insights. While the PMO is not collating reports and the data (because the AI will do that) they should be the ones driving the insights. The PMO does need to know a little bit more, but it is not an unanimous situation, which is a big misconception, that PMO are just the police. That is not the role of the PMO. Today the PMO should have a servant leadership role, it is about enabling the project managers to do their job well. It is about having the confidence to say "there is something wrong here" and I might not know what it is but I know somebody that can help. We brought in all our project managers and taught the how to do the coding, how to do the configuration stuff. Because they need to understand how it hangs together. They need to be able to answer and confidentially know what they are talking about when they are with clients. No one should be ignorant how everything works.

Interviewer: Thank you, what about tolerances, is this set for the AI analysis and how does this work?

Participant: We set tolerances like I said before, and our analysis and the systems do the analysis based on this. So yeah it's pretty simple really.

Interviewer: Okay, sorry for my repeated questions, but how does that work then? What happens when the tolerances are overdue?

Participant: Well the tasks or whatever being analysed are given a status based on RAG, red, amber, green if you've heard about it. It's fairly straight forward just that if you want to dig deeper you have to look into what I said before about you have to know "why the computer says no".

Interviewer: Thank you for clarifying. Is it only the system that can set the status of certain tasks? Like put a status as red or amber or change from red to green?

Participant: It has been able to do that, it depends on the project and the circumstances. Basically everything is possible since we bring in the system for them.

Interviewer: Thank you for clarifying. Can you say that the system is an early warning system for the project manager?

Participant: Early warning system or decision support system it essentially brings in another brain to the project and sometimes it's early warning, other times it's to be honest too late and a support system to identify somethings need attention.

Interviewer: Interesting thank you for clarifying, I'd like to ask about complexity, what do you think AI can do with complex projects?

Participant: Generally, complex projects have more people and more stakeholders. I think that's where we need to take more human elements. If you look at how complex project PMOs work, they do many things automatically. The number of stakeholders makes it impossible to apply every single one. Complex projects require much more standardized approaches, because stakeholder number one and stakeholder number two may want different things. In normal projects that is manageable, in complex projects we need more standardized approaches so that other stakeholders are able to look at the Unknown Unknown and see what's coming. They can focus on that rather than the technicalities from day to day.

Interviewer: Regarding areas for automation, do you keep certain areas for the human element even if this activity can technically be automated?

Participant: It's about finding the right activities to automate. People ask if we should automate everything? We should automate the stuff that are appropriate to automate, for example a lot of talk about doctor apps and health apps. Would I be comfortable speaking to an app about symptoms? Probably not because that app requires a role of a human element. I think it's about finding the balance from a day-to-day project management perspective, we automate what we can which tends to rely on the planning, scheduling and reporting. But I would not necessarily want to make quality checks automated for example. An AI at the moment will not be able to tell me whether my project initiation document is of good quality. We get questions from clients and a lot of the things we do can be automated, “I think I'm an advocate for that as long as we then don't push it so far” down as for example the doctor app. You can just chat with a bot and they can tell you what's wrong with you but I think I rather look a doctor in the face.

Interviewer: How about human interaction and AI interaction. Would your client always want the project manager face to face experience?

Participant: We have not found any clients saying one thing or the other. There is an ongoing debate between project manager and PMOs. Where PMs say if we just automate the process we don't need the PMs” and the PMs and say if we automate the reports that we don't need the PMO. There is also an element where PMs will need to get their hands dirty and talk to people, if you automate too much you lose the relationship. The relationship in networks is fundamental for us. People get jobs through their network, people change their lives through their network, people buy homes through their network. That human relationship is fundamental to project management. If you ask anyone in industry these days what are two skills project managers need, they will tell you communication and influencing skills. It does not matter how good the bots are, you will never replace having a coffee and have a chat. We are humans, we need human interactions, we fundamentally work within tribes. That's how we survive, it is important we don't lose that.

Interviewer: Okay thank you, lastly, a more hypothetical question. You refer to the human element. I will ask a question about the future. Will you be able to have a cup of coffee with an AI bot in 20 years. Will people care to know that maybe their chat conversation is with a bot and not a human?

Participant: There is stuff different generations don't understand with technology. It doesn't matter how you explain about some things to certain people from an older generation, they grew up in a different era. In 20 years I think there will be some things that we can't understand. If I look at the youngest generation, it drives me insane that they are glued to a phone. They don't remember a time before social media. I rather have a conversation with another human, I think a younger generation would react very differently to an older generation. My generation will struggle with the interaction with non-human, where a younger generation will be ok with that. I think there is a clear generational gap, I will never get my head around talking to a robot and feeling Enlighted from that conversation whereas a younger generation will be happier with that to some level.

Interviewer: So we are coming to an end for our set time, is there anything you want to add to this conversation?

Participant: Well it's a big topic and I could talk forever it feels like. Is there anything more that you wished to ask me?

Interviewer: Hmm I don't think so. I agree it's a wide topic and at the moment I am trying to pin down my research. I guess if you have time I could ask a few more questions. If you have time?

Participant: Absolutely go for it.

Interviewer: Okay yeas I really appreciate this, I appreciate you taking your time and stay a bit longer. I would like to ask about when a project is red or amber. I am looking into escalation and project escalation then, of course. Is this a term you are familiar with?

Participant: Yes, I mean, for me it's a common term when it's going bad or a situation is not under control. Is that what you are referring to?

Interviewer: Yes it is, project escalation is researched quite a lot, essentially it is when a project is failing and project success and failure is much studied by researchers. So to clarify my question, how to you act when a project is escalating, in other words when a project is showing amber or red?

Participant: Well I did explain a bit what happens when the project is red, sometimes the team can go in and change it, but what we do depends on the task. If it is a highly critical task and the red is confirmed critical, we have to understand why, back to the "have to know why the computer says no". I am encouraged by my senior sponsors to take corrective action, but prior to this I need to know the best option because there is no going back after making changes. I don't know what chain of reactions I will set in motion if I start to move resources around and so on [willingness to take corrective action]. Sometimes things sort out themselves and sometimes they don't. It all depends if we can rely on the AI [trust in AI model]. What is to say that the project plan is not correct [confidence in original project plan]? Circumstances will always change and the original project plan can still be the best option for us. If we wait out the situation it might be in favour for us [escalation of commitment].

Interviewer: Does everyone accept this classification of red or amber? Have you experienced any conflict when this happens?

Participant: I mean when we have a new client or a project team which is not used to authority and not used to having a system it can be tricky for them to accept that they have not through of everything. Some people are stubborn and just doesn't accept being wrong. Others have already promised too much and don't take responsibility to change it.

Interviewer: Interesting, are these situations common?

Participant: Yes and no, like I said it's common in new clients but I mean the over-promising happens all the time, or at least when the stakes are high.

Interviewer: It would be interesting to talk more about this, would it be okay if we set another time in the future to talk again?

Participant: Yeah that would be an issue.

Interviewer: I appreciate that, my research method is based on an iterative process and it would be interesting to talk again.

Participant: I agree this topic is very current. I'd be up for it.

Session 2 March 2021

Validating causal loop diagrams (recording lost due to computer break down)

P4 – Total of 2 sessions

Session 1

Interviewer: What is your project experience?

Participant: In November we did a survey about the amount of penetration of a AI into the project management world. Hopefully that can be an annual process. I have a half a dozen non-executive roles for smaller companies. Been in these roles for many years. Have been doing lots of different things.

Interviewer: Thank you. Can you explain your experience in project management and AI?

Participant: I have experience in AI and project management, but not many years back. Still hope I can be of use here. That is because we are in the beginning of something, it is not a mature market. In two years since we started to look at this no one was talking about it. In the last six months there has been a lot of rhetoric attention and even you guys got your grant approved. The APM carries a story in this area or related to this area at least monthly if not more PMI does the exactly the same. Hopefully we are all pressing the way. My background is I've got a degree in the business studies, the master's in information system. As I became more experienced I ended up in program. And then somewhere along the line it got slightly more blurred between supporting us and delivering projects or programs. Now as you know we have developed an algorithm for projects.

I became interested in how you could apply AI to project assurance. Generally speaking about assurance, once you've created the plan of the scope, as a human you ingest all the documents and information available about the project, you assimilate that data into some form of information. You compare it to your own knowledge or to best practice. Then you make a series of recommendations back to the client and then on the back of that you publish a report, and possibly the consultancy model is then to support the implementation of that. Given what I've just said and you think about it from a technology point of view, our basic premise was that we can apply AI in some form. That could be through a lots of different lenses to assurance, it brings a new perspective to the project. We started this journey on the assurance fixture.

Interviewer: Interesting, can you explain what you mean with "assurance", please expand on this?

Participant: Oh with assurance I mean like a third part validation, a second opinion you can trust. The system would work as a second opinion assuring you how the project is doing. Sometimes I tell clients it's a health check.

Interviewer: Can you explain your definition of AI?

Participant: My personal opinion is AI is a current buzz word that has to do with anything about computing. It is part of evolution with the fourth industrial revolution. I don't think that is a

correct definition, but it is now how it is being used. But in terms of what we say to clients, it includes learn, predict and automate. Very generally, the arguments are either drive efficiency or “the robots are coming”. People in business generally believe not “robots are coming” because they believe in efficiency. It is more the “socialists” who believe “the robots are coming”. Generally, I have spent my career cleaning up messes from larger consultancies.

Interviewer: What is it you offer your customers?

Participant: We've done a load of market research and spoken to lots of companies all major corporates. We employed a marketing student who is now in our employment. We research the reason for project failure. When you look at the market people are jumping into planning and scheduling. As our MVP we created a maturity assessible tool and then defined seven foundations for projects success, e.g. plan, budget, project team, etc. Basically that is a tool that work as workshop bases and we're almost finishing a survey with one of our clients as well. The survey gives a visual representation of their view of their maturity and confidence facing me on a two by two grids and you know high confidence vs we are poor at something and we need to do something about it. It then compares that to a what we believe are the appropriate things to attack when you manage a project. There is a lot of debate about this, whether governance is more important than the team or is planning more important than others. We have compared experience, but we have also done research. Which we know the answer to, business requirements. Another thing that also came out of the research was interesting, it didn't matter what industry sector, what method was used or the size of the project. The failure rates was alarming, and it is ridiculous across all sectors. Quoting APM and Wellingtone 30% of normal projects rising to 70% including IT projects fail. Depending on the story board, there is millions lost to the UK economy.

Organisations basically reset the business case and then claim that they have delivered to plan. We did all this work around project failure, and we created this tool if you like. We then went to the business world thinking about versions of a MVP. In the last three months I have been reflecting of the use of AI in project management. We published an article where we basically graded the marketplace of tools into four categories. One of use of chatbot and communication, opposed to automate the risk logs, what ever there is, “there is this path of automation for this.” “Then there is the other side, predictions, which I think is the holy grail”. There also one more, the robot-PM, where you take the human away. The automation bit is all about taking the administration of the project management process and actually when I say automation that could be deployment of a certain product, or It could be some development for people as well.

Our idea is all that stuff about releasing effort into the system. Let’s say you automate reporting, which “saves an arm of a person per week”. You need a big community of project managers to

release a whole project manager and making efficiency. That lends itself to larger companies straight away. We also did research about which companies are likely to buy consultancy services, which are likely to buy project tools. Basically corporates, with a mature PMOs setup. Start-ups do not have the funds for that. We did our segmentation of the market for that.

On the prediction side we are much earlier. We have been working on a data model. The thought process behind that model is corporates are likely to collect data around planning, money (budget), time and resource. We are focusing our efforts building the data model associated with those areas and where we can ingest on volume in project registers (documents). We are trying to which projects do really well and which do really badly and the idea is to acquire some quick wins in each of those segments.

Interviewer: Can you clarify what you mean with project prediction?

Participant: If you can intersect projects in their lifecycles before they go wrong then that's where the savings lie. My jump by it without sufficient case studies, is that you do it as a portion of failure for a company. The areas I mentioned before (planning, budget, time and resource) in delayed project time, there is a cost associated with this, which companies do not really look at the moment. The maturity of the industries is that they look at individual projects, so I don't know the answer, but what is the opportunity? My mind goes back to delays. You can get very attached to a project plan and the data you are using for your predictions. You may rely too much on the data and that shows on low maturity, but as when the project generates data and you can go away from the planning data, then you can know better that you are on track. Because if you have too much confidence in the original project plan then you are in bad trouble, and you won't know until its too late. If you can predict something and have the right data then it will let you know if you likely are on the right path. Our data model is key and then it can be applied to any of the seven foundations.

Interviewer: Interesting, thank you. Can you clarify what you model does and how it can be used.

Participant: Yea certainly, I think I wasn't very clear but is a data model where registers or documents or other types of data really, as long as the data is clean, you can use the data model for this and find relationships in the model, or data I mean. I am not a very techy guy with the terminologies but we have used the tool for clients and then I am the inbetween guy. I talk to the client and our programmers.

Interviewer: Can you expand on what you offer your clients?

Participant: Yes, anything from meeting to setting the foundations. How are they operating? I say the human process because it is not automated. There are tools in this area, but they are two dimensional, e.g. excel. BI (Microsoft PowerBI) is starting to get there. When I talk about human process I mean, "how they currently deliver projects". From that readiness assessment, a transformational process comes out, based around set of phases and transition steps. The first phase being quick wins which are normally about the human process, the lack of human process, the integrity of the data or all the gaps in the data. This is where our mindset is at the moment and we are generally opening doors and having deeper and deeper conversations. We are we are early in this market. Seeing a lot of interest, but many are confused or just want to know more. They feel stressed and obligated to do something but they don't know what to do. When we talk to them they are stressed and think they are missing out, I don't think they are because it is early. Many don't know where to start and that's where we come in. We help them from the start, and we start with the processes and the data.

Interviewer: Can you share what companies you are working with at the moment?

We have X corporates in our closing pipeline. Some that are closer to closure than others. I'll see if I can hook you up with some of my contacts it you want.

Interviewer: Thank you, that would be great. Can I also ask who is your competition?

I would say the big consultancies, McKinsey etc. Smaller competition are less known. We and them have looked at PM tools in the last 6 months it has moved in rapid range. Where it has moved most is planning tools. They are gearing up and it is coming. We focus in short term on seven foundations, areas which can provide tangible data. That ignores (in short term) governance, business change and softer sides such as benefits. I won't be able to create a planning tool, but I can come in as a consultant and recommend those tools and work on the prediction side.

Interviewer: So if I go back to your data model, if I understand correctly, you offer a full transformation in your client's processes. You go in and analyse their processes, identify where there are gaps, how they generate data and the put that into the data model?

Participant: Yes you can say so. The data model is our brain.

Interviewer: What happens then with the data model?

Participant: Well it depends on the client and if the data is successful. The model is used for prediction of the project. We are in the beginning of this phase but can see some progress already, I really hope that it can get more traction coming year.

Interviewer: Sounds very interesting. What areas can the predicition tool be used on? For example, is it then running an analysis on the schedule or costs of the project? Can you expand on this and user areas of the model?

Participant: Ah okay, I think I see where you're going. I can say that it all depends on the model. If we have data for project costs it will do predictions on this, like so for other areas. If it is planning data we can predict this as well. We focus on the seven foundations.

Interviewer: In your opinion, what makes a good project planner?

Participant: I think of it in more broader terms. You can educate yourself to a certain level, we are doing a piece of work for one of our clients to make their project managers rock stars. We are looking at the softer side, not just the person at the front of the room but also at the back of will room. Link that back to AI, if you could make the mundane administration work automated, it allows the PMs to focus more on the softer sides. For major programs I think it is soft skills. We live in a structured world and focus on structured methods. "When we get through this low level of maturity, very generally, AI will allow the softer skills to take space."

Interviewer: Can you expand on what you mean with AI will allow softer skills to take more space?

Participant: Absolutely, when the AI performs its prediction, you as a project manager will have more time to make decisions progressing the project. You will also need to consider the AI's analysis in the decision. Let's say the AI is indicating a risk you will require to either act accordingly or to go against it. Which leads to loads of other questions, such as escalation of commitment, and justifying the decision based on machine learning which in itself is challenging.

Interviewer: I am not very familiar with escalation of commitment, how does this differ from escalation?

Participant: It is the same commitment is the theory behind it I think.

Interviewer: Ah yes, I remember now, thank you. What other challenges do you see in this space?

Participant: Well there are the people change process and also a technical challenge. It depends on the client, but we can do both.

Interviewer: Where in the adopting process are your clients? Do you prefer clients with a certain degree of maturity?

Participant: Yes because the sell is easier at a certain level of maturity. Many time the maturity level is way off. I mean if you don't know that your organisation is immature then you will think you are mature, classic thing for young adults as well. Teenagers think they are mature and adults, then you realise that you are just a child at least you don't know it all until you get up in age. Same with organisations, they all think they know it all but actually they know a lot less. We come in and help them realise this essentially. It depends on the client, some have great people already understand it, we work a lot with changing their mind. They need some data processes for us to work with them, but I don't mind working with any clients as long as they are committed.

Interviewer: Do you see any other challenges in this process?

Participant: Well I mentioned a few, the technical is obvious, the change process I mentioned before I think. I can't not say the data challenge. The data model is based on getting data so it is a questions of managing this and setting this up. Not just a one time thing. It depends on that we understand the organisations to 100%. It takes time, and we may not be able to charge at first. We do the assessment pro bono if necessary and then we can charge when the client sees the work. It's how it is, we are working on it but can't change it at the moment. I think it will change. So that is a challenge in itself, we need to be able to charge our clients, but we're doing okay at the moment anyway. It's roller coaster, we see all kinds of stuff, some are serious and others are just in for the short run. We are here to stay so we are not in a rush so to say. I hope that makes sense. Other challenges are obviously regulations, GDPR is one of them. We need some strong policy makers to make this work. I'm positive though. We have a great team and I am enjoying it. We I believe strongly in this so it is a matter of patience. Not sure if that is all challenges but it's what came to my mind now.

Interviewer: Interesting, thanks for sharing that. Where do you see the future is going?

Participant: Besides AI analysis, I believe that the "robo-PM" (robot project manager) will become bigger. Depending on how far we are looking but in early years small tasks will be automated. Such as small business cases. A lot of that is done by a PMO administrator. Do we need a person to do that?

In terms of taking humans completely out, for the short term it is only those smaller projects, within RPA (robot process automation). The angle we are taking on is the larger company domains. Where we take arms and legs of people to save for examples 20 arms. Then you have to cluster them together to save a whole person. The other area is the PMO where people need to be sent on training. In short terms, within 5 years, there will be automation and some casualties in the PMO. If I would show your or product it would work as an app.

Interviewer: Where in the UK do you see is most active in this area?

Participant: It is all depending on where the HQs are. The trends are following the HQs. I am engaging with all industries. London is obvious and also where you are down south. I don't think its limited to an area. It will hit us massively everywhere in my opinion.

Interviewer: Thank you for this explanation, I see we are almost running out of time. What other opportunities do you see in AI and PM?

Participant: So we have this AI side around workflow and prediction. We go in with our AI readiness service, the idea is that we can go into an organisation and look at their data, products and systems. This link back to the other tool I mentioned. The tool is a rapid way to put the foundations right and then on top of that we look at the systems and the tools. We can then help you deliver it and take you on this journey. As a consultancy firm, we will support you on this journey. Because we are more mature than the market, clients are sort coming to us inquisitively, which is an easier sell.

My average conversion rate months and growing. We are early in the market and it is easier to sell a traditional consultancy which surrounds assurance, human process, is your governance process good etc? If you then go back to that AI readiness assessment what we're assessing there is three folds we're assessing the human and the project process, the automation opportunity and the prediction area. Essentially making sure where the company is at and what level of AI they need.

Interviewer: Thank you for your time, I believe our time is up. Is there anything your would like to add to this conversation?

Participant: Thank you, it was interesting, I hope you sort of got what you needed. I don't think I have more to add.

Interviewer: Would you be interested in participating in the research for a second time? It would be useful for me and the research since I am using a iterative research method.

Participant: Yeah why not? I don't see why I wouldn't be able to do that. I am going away on travels next month, but can jump on a call if needed. When where you thinking?

Interviewer: Oh I haven't decided on yet, I need to digest this information first and then I can reach out to you if that is okay?

Participant: Sure sounds good.

Session 2:

Interviewer: I appreciate you coming back to this topic and my research.

Participant: Thanks for having me again.

Interviewer: Last time we spoke you explained your prediction tool and data model. My aim is to focus more on project escalation and the use of the data model or prediction model.

Participant: Okay sounds good, happy to help.

Interviewer: Do you look at the data or AI prediction yourself?

Participant: Yes and no, mostly its our data scientists, can also be PhD students. We do collaborate with organisation who has experience of data science in other industries. Gradually bring that inhouse.

Interviewer: Just to clarify, what do you refer your model or tool as? Prediction model or data model or something else?

Participant: Well mostly data model or prediction model. It depends what the client is using.

Interviewer: Cool, excellent, we may of course discuss other topics as well. Escalation is a big topic, in research it comes up during project control. But also in research of project managers' decision-making.

Participant: Ah yes definitely, was there a question there?

Interviewer: No, no question yet. I would like to understand more about your prediction tool before going into the other areas. Would you say it is possible to use your tool for control of project progress against control measures?

Participant: Hmm yes and no, depends again on what data. We have to do with the data available. We can but measures against the predictions, some small scale of this is done at the moment. The prediction is set based on a few parameters and if the predictions are not aligned with the measures. We use the data model to make up the prediction tool. What ever is in the data model is what the system can do. Should I go through what it does? I talked about it last time. As the project continues [project progress], the project generates new data [project data generation] and we can use the updated data to improve our model. We are then also able to improve the trust in the model.

I believe the generated data [project data generation] is more accurate to use than the data we used during the planning phase [cognitive anchor to data]. I would say that. Let me think. This [project generated data] becomes real [cognitive anchor to data] for me after a while, the project has to run for a little while before I can rely on it [medium term delay]. It goes way back. Just as

the trust in the model, this can be overturned by other feedbacks related to my willingness to act [medium strength feedback].

Interviewer: Not that's not necessary, I will try to be more concise with my questions today. But would you go so far as calling your tool a project control tool?

Participant: No I wouldn't, it would limit what we do with it. We do so much more in my opinion. It predicts how the project will go first of all, and then maybe second or third you can say it can be used for control. It all depends on the client. We use the seven foundations that we have set through our own market research, our seven foundations for project failure or success.

Interviewer: Interesting. Last time you mentioned escalation of commitment. What is your experience of this? Do you agree with research suggesting it often happens during project control?

Participant: Ah escalation always happens sooner or later, it's a question of how do you deal with it. Escalation of commitment is big, lots of theories but also a real problem in projects. I agree it happens, but would say it can happen anytime.

Interviewer: If you expand on this a bit more, what is your definition of escalation?

Participant: I think I would just say it's when something goes wrong. It can be anything really. But when something doesn't go as planned.

Interviewer: Do you have your own experience of escalation?

Participant: I guess I do, even if few want to admit that. Things always go wrong, it becomes a question of how you deal with it. You can choose to ignore the warning signs but it will get back to you later one way or another.

I feel that I can justify to wait out the problem [escalation of commitment] because it is the default stage [short term delay] if I have confidence in the project plan [confidence in original project plan]. It will require quite a lot of evidence to finally act on the warning sign [strong feedback].

Interviewer: What do you mean with warning signs?

Participant: Well we never say it but no one wants to hear bad news. So I mean bad news I guess. Any warning or indication that the project is going badly would is avoided if necessary. I have heard about meetings being avoided so that the project manager would not receive the news of that the schedule was messed up. Yeah it's really bad sometimes, people do anything to avoid taking responsibility it feels like.

Interviewer: Interesting, there are research on this suggesting that project managers have cognitive limitations to take in warning signs. What is you take on this?

Participant: That is probably true to some extent. We all have our limitations. Optimism bias is big and confirmation bias. If you only look for what you want it is all you will see. When you a buy a red car, all you see is read cars on the roads. We are just humans after all. Some project managers are very good at their job but they are still only humans not superhumans and they make mistakes.

I feel that the more I am willing to act according to the warning sign [willingness to take corrective action], the more I will trust the model [trust in AI model]. This is good as long as the AI performs well, it can be vicious cycle if I trust the model and it starts to make poor suggestions. So that's that. When I finally decide to act [long term delay] on the warning sign we have to act fast and accurate, it overruns other factors such as the trust in the model and not willing to take corrective action [strong feedback].

Interviewer: Is it fair for me to think of your tool as a prediction and control data model of your seven foundations? And project control being part of that?

Participant: Uhm, I think that works. Scheduling and planning needs control so on a meta level that works. We don't talk in those terms though.

Interviewer: Excellent, thank you. I would like to combine the thoughts on the use of the prediction tool and control and escalation. What happens when the prediction tool is used by the project team?

Participant: Ah okay, well it give a prediction based on probability. The probability level is then set based on what seems necessary, some teams go for low probability and others for high. Then decides if it's worth doing. It give assurance to a certain degree, some follow it by 100% others are in more complex conditions and will consider it after certain time. "…if I am actively looking for rework and willing to stop the escalation [willingness to take corrective action] then I am more likely to find delays and tasks that need attention [rework discovery].

I am actually happy when we find delays and tasks that need redoing [willingness to take corrective action] [rework discovery], this means that we do a good job and it creates more training data [project data generation].

Interviewer: Okay I understand, so let's say that there is a scenario where the prediction tool is saying the scheduling will overrun or similar. What choices does the project manager have?

Participant: Well either do nothing and continue with the project if the probability is still okay or do something about it. Usually it takes time to identify whats wrong but the process of error analysis takes place. It can be tedious but we try to improve that as well.

Interviewer: Ah okay, so the project manager for example, have different options, let's say when the model predicts something significant and above the threshold of probability saying that the project is escalating. What do you do then?

Participant: Well when its been me who is in charge, usually its me or the client's project manager, or sometimes both of us, we have to go through our decision process for escalation.

Interviewer: What makes you follow the prediction model? Does this differ anytime?

Participant: I mean yes and no, it differs when the model has not performed well enough, but then we raise the probability level for next time.

Interviewer: Okay, but before you raise the prediction level, or sorry the probability level. How do you come to this conclusion that the model is not performing correct? What makes you take the decision to raise the probability level?

Participant: It goes through the team and we discuss what is happening. It makes us take decisions together. I think we find some models perform better but its always a learning curve and we never settle. It also depends on the data.

Interviewer: If we focus more on you as the decision-maker when you have the role of taking in the prediction models analysis. What is the first thing you do when you see the model goes over the probability level?

Participant: Ah okay, if I only talk about myself I go to my client and share this information and we discuss whether or not to take action. We work in a team so rarely I make these decisions myself.

Interviewer: Okay I understand, is there any doubt that the model is correct?

Participant: Haha [laughing] well yes there is. There is always some doubt I would say. We never know 100% the model is correct, it can be errors in the data. So no but we have to make the best with what we have.

Interviewer: Okay so if there is doubt, what is this based on? You mentioned the data, is this a source of concern?

Participant: Yes it is, we do have data processes as I've talked about, but you don't know what relationships the model has found. There is no right answer where you can check and no one

sits on all the answers. With some clients there are more doubt based on their data, and the processes can still be a bit shaky. So I can either go against or with the model.

Interviewer: Can you expand that. The decision-process where you either go along or against the model? Can you expand on this again please?

Participant: Sure, I mean we make the final decisions right? The prediction model may predict something but will we follow it. Most of the organisations we work with are new at this. We set up processes but it depends on many things, such as how unique your project is, what type of AI model you are using, can you actually understand why the model suggests A or B? But anyway, if you don't really believe the AI is performing well you will be sceptical to follow its suggestions. We try not to deploy a data model that isn't working but you never know, it is a lot of learning by doing. It's the same with any team member, if they are not competent you probably won't think what they are suggesting is a good option. So there might be reasons to go against the AI just as you may go along with the suggestion if you really think the AI is performing well. Sometimes I just feel the project is too unique [project uniqueness perception] and it will be challenging for the AI to make sense of the data [trust in AI model].

It's like if someone shows you a plan and all the proof and background information for why that plan is the best option, if I am able to see this from the AI [AI explainability], I am more likely to trust that the AI suggestion is good [trust in AI model].

We usually spend a lot of time planning a project, and my confidence in the plan depends on how well we did the planning. If it is a very unique project, not much new data will help coming up with a better plan [project uniqueness perception], the new plan will be just as good as the original one. I will still believe the original plan is just as good [confidence in original project plan].

I tend to see myself and others have a tendency to believe the project we are working on is special, it's our little baby [perception of project uniqueness], and is sometimes used as an argument not to trust the AI performance. Essentially it leads to the team and I not following the AI analysis. [override AI bias].

Interviewer: Hm interesting, thank you for this explanation, do you think there is a way to prevent these challenges you are mentioning?

Participant: Well its about having a solid process, you can't just make a decision based on anything. The AI should complement your overall decision-process. If you choose to escalate the project based on your analysis you need justifications, just the same with if you apply AI predicition for identifying risks. What makes your analysis go against or is the same as the AI? If

you choose to correct the path of the project, is this with or against the AI? Same as when you choose to not do anything, to continue the project, why is this the correct decision? These are sometimes philosophical questions, but its part of the role of the decision-maker, we want to do whats right for the project. In theory you will have the same arguments all the time, but I find that sometimes there are more rigorous processes for certain decisions, you need essentially the same justifications for any decision.

Interviewer: You mentioned before that you have a level of probability, but you can adjust it, did I get this correct?

Participant: Yes basically yes, after testing the model we can adjust the model accordingly. Sometimes, we can raise or lower the level of probability depending on what we have seen.

Interviewer: How does this affect your decisions? If you change the level of tolerance so to say?

Participant: Well we adjust our process accordingly. Almost all the time there will be a discussion, what should we do? How the model performing etc.

Interviewer: I understand, this makes me think of accountability when model is used. What is your view on AI accountability and responsibility of the predictions if you can say so?

Participant: Well it is always us human who make the decisions. No one else can take responsibility I think.

Interviewer: Do you think the challenges for taking mitigation actions are the same as choosing to continue the project?

Participant: Well I think it depends on the project and again what type of AI the project uses. Trusting in the AI is big thing now, at least we see this. If you don't trust you prediction model and know the data is high quality you are not likely to follow its analysis. It then almost work as an opposite influencer. Your previous experience definitely with the AI performance affects the trust. But this can also change during the project. For example the model may perform worse in the beginning of the project, but as your project generates data and the model learns, it can make you change your perception of its performance.

Trusting the model [trust in AI model] is key, if my team doesn't trust the model it will not be possible to follow the analysis [willingness to take corrective action] if the model says the project is running behind. It [trust in AI model] goes on constantly from the start [short term delay], but it is not the only thing that matters, my willingness to act and trust in the AI model weighs heavier [medium strength feedback].

Interviewer: You mention trust, is this something you talk with your clients about

Participant: Sometimes, yes sometimes no, we use different terminologies. It comes down to how much you can commit to the technology and the data, it will reflect the confidence, or say trust, that you actually want to use the model. It is big part of PM methods and the change management process. We use this for some clients who do not really accept the model or thinks it's the wrong focus. It's a parallel process of using the model and working on the users' change process.

Interviewer: Do you invest a lot in the change process that you mention?

Participant: It depends on the client, we try to go with clients that have some maturity already so we don't focus 100% on the change. If the client asks for this we try to say no cause there are other better fit for this. We want to focus on the data model and prediction of the seven foundations. At the same time we realise things change, people switch roles etc. We have to make an analysis on what we see, and if the model is not use right we might need a workshop on this topic and "convince" with a nice word that their minds need to change. But no we don't invest much on the change, we don't want to focus on that but we cannot ignore it.

Interviewer: I understand. Thank you for clarifying. So you have shared a lot of things today, I really appreciate this. We have talked about controlling the seven foundations, hmm also escalation and then trust. Is there anything else you would like to add?

Participant: Hmm I don't know, it's been very interesting digging into how we use the model. It made me think of how we can improve also. So thank you back. We are far from perfect. It is also very new so we learn while doing. There are many thing we could dig into more I feel, everytime I talk in a macro perspective my mind drifts and it feels like the topis is just scratched on top. No one can know everything I guess but it triggers me to learn more. Is there anything you can share that you've found already in you research? How much do you have left to do?

Interviewer: I have a few terms left at least, I am collecting the data and writing at the same time. It feels like a manageable thing at the moment, doing these digital interviews is interesting but yeah covid makes everything a bit mor uncertain. But I can share that it is very interesting to hear different perspective. I really appreciate you talking to me again. Your thoughts match with some others I have talked with. There is a lot talk about data and the quality of the data.

Participant: Yeah yeah yeah, I get that, it's a big topic you have. Glad to hear I am not far off in my answers to you haha [laughing]. I guess its tricky to know what you are after and then answer accordingly but I do my best.

Interviewer: I am really just interested in your perspective, so it's just your own experiences and words I am curious to hear about. I would appreciate to keep in touch if you don't mind?

Participant: Of course, that would be great to hear. Even for me stay up to date and see where things are going with you.

Interviewer: We didn't really reach a full hour but I work iteratively so I rather digest all my data then come back to you will follow up questions if that is okay? I use something called causal loop diagram and maybe even some simulation. So there might be some things I can show next time. Not sure when though it all depends. I might be in Sweden then it depends. SO I will stop the recording now.

Participant: Sounds good.

Informal discussion after the recording was stopped. Notes taken from the conversation:

The participant states that AI trust can be misinterpreted. It's more about other factors, the data, the seven foundations, the technical skills.

P5

Interviewer: Can you introduce your organisation?

Participant: We exist because the experimental process of learning how projects are completed and the difference between the plan and the actual is inefficient. There is no other means to solve this other than through data. Individuals are simply not going to be able to get enough experience to truly go down a path of improving decision quality.

Interviewer: Do you only focus on the Gantt-chart scheduling process?

Participant: We just plan what was planned to happen and what actually happened. Transpose that into a probabilistic model of risk.

Interviewer: Is this a one time solution you offer or do you update the model with new data?

Participant: It can be either, it is certainly flexible. Because it is an algorithm it can work at any stage of the project with little no manual effort provided by a human team. So both, it can be on the frontend of the project before it starts, it can be during the course of the project and identifying changes in risk profiles.

Interviewer: How do you access the data you use? Do your clients share this data with you?

Participant: Our clients share their data their data with us.

Interviewer: Can you help any client or can you help organisations become more data management efficient also?

Participant: No to your second question. To the size yes, we do only work with a revenue around $ 1.5 billion and have at least ten years of historical data.

Interviewer: Do you share the data among your clients as well even if it is anonymised?

Participant: We never share the original source data with anyone.

Interviewer: Can you tell me the next steps in the process? Do you outsource any staff e.g. data scientists?

Participant: Everything is done inhouse. We outsource nothing.

Interviewer: This must be quite a unique position. Is there any competition to your organisation?

Participant: No, there is no technical competition in the world that can do what we can do yet. There may be someone who has started with similar but no one we are aware of.

Interviewer: How would you define AI?

Participant: I think of it as an automated system that is capable of self-improvement with additional data. I don't use a definition. I don't mention we us machine learning in our product when explaining what our solution does because that does not matter. I can have a monkey running around doing all the work. All they [the clients] care about is what utility does it provide? What function does it serve? And is that function valuable for me? We just focus on that. What tech exists in the back, we can go into it if they are interested, but more often than not they are not interested.

Interviewer: Do meet any people who are sceptic of what you can do?

Participant: Yes, in every new technology there will be sceptics of it. More so in this space, because it is a forecasting system is even more prevalent. For anyone to accept a forecast there is a significant journey to go on.

Interviewer: Are the scepticism due to not trusting the data or not trusting the predictions themselves?

Participant: It is about if it is possible to figure out how long the project will take.

Interviewer: Considering the size of your clients, are they not able to build a similar solution to yours by themselves?

Participant: No, they would not have the technical mean to be able to build this themselves. Not only is it complex but no single organisation has the data themselves to do it themselves.

Interviewer: Why do think the market is not mature in this area?

Participant: Because it is inherently generating a forecast. When you generate a forecast you go head to head with an intrinsic opinion that an individual may hold. How does the individual who is receiving the forecast accept or believe it is legitimate? That cultural shift to move decision making opinion away from an individual and deploy it into an algorithm is not a simple thing to do. It is not months of work it is years of work.

Interviewer: Is this the biggest challenge you have?

Participant: Yes.

Interviewer: Does your tool replace any decision making positions on a senior level?

Participant: No not at all, it augments them with better quality decisions.

Interviewer: Do operate on an international level or is it within the UK?

Participant: Internationally.

Interviewer: Is there any projects you are working on today?

Participant: The only one I am allowed to say is HS2. The others are still confidential.

Interviewer: Where do think your organisation will be in five years?

Participant: We will focus on the scheduling solution. It will be in a far deeper product that will go well beyond the management of the product. It will go into the finance of the project. We can underpin how long the project is likely to take and also come very close to underpin the likely hood of the project being delivered for their cost profile and their economic profile. Playing in this space of being able to understand projects' finances and economic behind the project is something we want to expand into during the next few years. The financial side of construction projects.

Interviewer: Where do you see maturity level in the construction will be in five years?

Participant: In five years we hope the industry is comfortable in taking multibillion dollar decisions using data rather than the opinion of a few.

Interviewer: Have you found inspiration from other industries when you created your solution?

Participant: No not really, we have focused on the problems in our own industry. Forecasting systems of this scale is just not relevant elsewhere.

Interviewer: What arguments do you use when you meet scepticism of your solution?

Participant: They usually understand the problem we solve or they have a sense of the pain which is caused of the manifest. They don't care how it is solved, they just want it solved. Those are usually the strongest advocates. The ones who are against it are the ones who don't get it. They don't see the problem, so they don't see the point of appointing a solution to try and solve something.

Interviewer: Do you focus only on a certain type of client? Or do you also see it necessary to sell to client who "don't get it"?

Participant: There is always a bit of natural selection. The people who don't get it or don't like it we won't interact with them. You can have one conversation with someone.

Interviewer: This is very interesting, I appreciate that you have taken the time and talk to me. I think I need to digest this information and maybe it is possible for us to discuss this topic again at another time?

Participant: No problem, absolutely.

Interviewer: Is there anything you would like to add to this conversation?

Participant: No I have nothing to add.

P6 Session 1

March 2020

Interviewer: What is your project management experience?

Participant: I have software and agile project management experience. Do you want to know what organisations I'v been with?

Interviewer: The specific organisations are less relevant, just explain some of the project roles you've had, please?

Participant: Sure, I've been a programmer and also business analyst you can say. And now part of this company I am working with now.

Interviewer: What is your experience of AI?

Participant: I have worked in many different areas. I have worked with different types of algorithms for ages, some can be said to be AI I'd say. Some neural networks, bayesian and regression. Some are more advanced than others. The most recent this is the chat bot I told you about. It has been very interesting and fun too.

Interviewer: Can you give some background to your chat bot?

Participant: The chatbot is called XX [anonymised]. The company was founded in 2014. When we started building chatbots we naturally we wanted to give it a character and a human feel. The bot operates within Slack that is how you interact with it. It does have other integrations outside Slack, but this is how we carry out those interactions or situations with chat bot.

We operate daily in Slack, share documentation and communicate. We do a bunch of other things which is part of our job, but we want to do it all through this way, this is the idea basically.

Interviewer: Who is using this bot at the moment? Do you have clients or so?

Participant: Not many yet we have one main organisation and then the government is interested in this stuff. It's also depending on them using Slack.

Interviewer: Are there any governments departments using Slack?

Participant: No, not officially, but separate groups. It all goes through department of communications, within that there are exceptions.

Interviewer: How long has your organisation used Slack?

Participant: I will assume about five years. Back then the bot did a few simple things, today it can do many things. It does our "dailies" virtually, we do it between offices and so right now the whole of the Swansea office will get together. Usually around 15-20 people. Like a scrum meeting. We could have a simple reminder to do those things in a corner face to face. But it gives you a warning 15 minutes before and it records everything that is said for 20 minutes after and produces meeting notes. It keeps a transcript of what we are writing.

We all take turns and it also does nominates the first person. It may say "Darren can you go first". The meetings notes are recorded and I could go back three weeks ago in "PlanMill?", it stores them in order to call panel which we use a bunch of projects, okay and we can go back and just see the transcript.

We have developed an app ourselves a PM tool for short-term work. It is a tool we developed in-house which tells the company long-term plan, for the next four or five months. They are planning on rewriting it so it is all under one roof. And we will bring other integrations with that.

(interview gets interrupted by a colleague of the participant)

Interviewer: Interesting. The impression is that you get a lot of freedom and autonomy as a team member, and perhaps some disorders, how does the chatbot manage "slackers", not responsible workers?

Participant: We record our daily work in another system. In the end of the day I go to the system or the bot. This gets summarised in a utilization report.

So it will say person X spend 100% of this time working on Y project. Essentially it gives you a breakdown of their utilization for the week. Say person X receives an invoice from the client, we cannot lie because it would flag that. People would not dare to say they have done things when they have not because it will be picked up. What you could find then is that it will say person X has only worked 50% of his utilization this week and everyone wants to know why that was a very red flag.

It does that once a week but the end of every day, if you haven't recorded the previous day's work, you get a private diet DM from the bot to say "you didn't do your hours for yesterday". So you avoid getting called out. It sounds strong saying "called out" but the way it words everything it is not very serious hehe [laughing].

Interviewer: Very interesting, there are few things here I would like to pick up, one is the monitoring of projects or hours spent on tasks, another is how it works. Is there no negative sides with having a chat bot doing these things?

Participant: For example, the bot has given me a message saying “just a friendly reminder of the people below that you haven't fully reported your work hours.” So it’s not very harsh I would say. You get a number of warnings before this happens. It has named and shamed three people basically for unreported hours from last week haha [laughing].

Interviewer: And it has gone out into the public forum?

Participant: Yes it has. It’s a forum with the relevant people.

Interviewer: What else can the Ai bot analysis do? If something is ignored who gets this sent to? Line manager or someone else?

Participant: We have no line managers. The only person, the MD above myself is one person for the UK office where there is only 25 people. There is 450 in Finland, distributed between two officers, so they would have someone responsible to follow up.

Interviewer: How does the MD get flagged on tasks?

Participant: He doesn't get personally flagged, he'll just see that those messages are being posted in the chat. Why he has a concern is that by the end of the month the general utilization gets reported for each office. It could say “75% of staff in office X have been fully utilized over the last month, whereas only 60% of staff in office Y has been utilized”. There is this kind of competitive between offices, so if people are seeing that people aren't recording their hours, they know that it is directly going to affect those reports.

Interviewer: So can you say it works as an incentive to report your hours?

Participant: Yeah, but we start from top down. We give daily reminders that you haven't done things yesterday and weekly reminders. We also give you daily room our weekly reminders of your actual utilization, whether you've missed hours. Only then we start reporting weekly to the whole channel that somebody is not doing what they are supposed to. It's very rare and we get to the end a month where someone has not done anything.

You are almost annoyed into doing it (reporting hours). Sometimes I don't like to do my hours every single day, but because the AI will remind me that I have not done anything yesterday and it gets us into the habit of doing things daily. You could argue that it's kind of an annoyance, but I would rather the AI, a chatbot, ask me then some individual”. “If a bot can do that, why do need someone to do it?

Interviewer: How would you define the chat bots main objective?

Participant: Hmm, well its to make sure everyone is doing their job, but put in a nicer way. We don't need managers looking over our shoulders and we don't feel chased by our managers as we used to.

Interviewer: Can you say that it's a control tool or similar to this?

Participant: I would say it's controlling our resources, it makes us increase our efficiency of resources and team. I want the best project manager with the best relevant knowledge of what we are going to do [project experience], then I know we will best chances to find issues quickly, call it a different way to see things [outside view] [rework discovery], and fix them.

Interviewer: I understand, interesting. Does the bot give any support as a manager does? The human side of managers, how to you replace that with the chat bot?

Participant: We get asked by the system every three days how we feeling. It's anonymous and it tries to get a feel for how things are in the office. It asks "How are you feeling today?" You get an option from: awesome, good or terrible or not sure. It will then tell you that if you want to submit a detailed response. This goes to our HR department, which are called "people persons". They are people who promote recreational activities such as mindfulness in the workplace. They asked for this to be part of the bot. It is broken down and in terms of locations, so my response is collectively and they are responding, but my name is anonymous. I believe that's been working quite well.

Interviewer: Interesting. Your organisation has previously been voted one of the best workplaces in some category, can you expand on this? Was this after you introduced the AI?

Participant: The X offices are great but um yeah so like and these things sound like really kind of smart. As a developer these, for example, when the bot asks how you're feeling today, it's like half a day's work actually. So we haven't spent ages on this specific feature. I think that we can make it better. But yeah I guess people [employees] like it here. I really like it here, people seem to stay for a long time.

Interviewer: What are the thing the bot does which a manager does not do?

Participant: The idea behind it was that we can have managers do this but we are all very busy we all kind of don't want to be asked and pulled aside to give them this information or feedback when we feel it is recording it anyway. They could gather this some way or another. That was the original plan behind it. We also wanted the flat hierarchy because it sounds good and it makes people feel good that there is no one above them we just have people that play roles within the company. To refer to your other questions why people like it here I think that is one reason.

But we have people who are important but we try not to give anyone management roles because then it tells you that someone is above you in some respects. “We looked at what managers do, and then we asked: can management be automated?” We saw that with a lot of things it can be. Sometimes you do have to step in as we said earlier, if somebody is repeatedly not recording their hours, somebody needs to step in and intervene. But because a large portion of the role has been already fulfilled by the bot it is actually rare that an MD does have to step in. They [the MDs] wouldn't mind taking all that responsibility as an additional piece, but they don’t have to now.

Interviewer: How does that work in practice?

Participant: For example, when I receive an utilization report and it is also statistics. They are just numbers, but they can tell you if somebody has not recorded their hours or if they are not happy. They may not have provided further feedback and it is anonymous, but if 50% or 10 responses saying that one office is not happy and we are also seeing that utilization is fairly low, then you can use that and identify that there is a problem and ask questions.

Interviewer: So what does the chat bot do in this sense of AI? IS there any analytics or AI in the bot?

Participant: It makes some analysis on the utilization report if we ask it to do so. It’s fairly smart but it still needs directions. It has replaced our line managers which is good but we can’t let it run by itself yet without any intervention from us. We use it to improve our overall decisions and it has worked well so far.

Interview gets interrupted by the participant’s colleague.

Interviewer: How does that work in an internal politics and hierarchy? Is there anything the chatbot can do in this case?

Participant: The HR, people persons are promoted to us heavily. Rather than directly tackle those problems, it is looked from a different angle. They are used to prevent those things from happening. This is why the organisation focus on being a great place to work, because it alleviates these things. I mean, there's been they do still happen, we still have had employees and some distressing times.

From what I've seen it is largely avoided purely because it is actually a great place to work, not just for the these automated tools like our AI bot, but even when it even when it comes to

recording hours we only need literally three word answer of what I did that day, they don't want to pressure you into answering.

Basically they try to get out of the way, but provide you with everything that you may need to do your job. As a result we do tend to be quite happy. Although we are sometimes, embedded into our client's teams and sometimes the environment there is not that great to work. When I was working for a previous client I had about six months where I was being overworked and I was not happy. I felt like I was not working for my organisation but rather the client.

But I had the confidence to go to the people persons and tell how I felt. I had their promise that they would try to help me in multiple ways they provided with additional resources.

Interviewer: Why did you not use the chatbot for this purpose?

Participant: Two years ago one of our office stacked low, around 30 to 40 percent of happiness across all roles. From that the company started to ask questions of why that was, and it encourages to open up about. It was found that it was because of during that time we moved into this bad office while other offices had all the good things. Suddenly the company solved all those problems for us so. We saw directly that if we are open about stressful elements, then they tend to get results, so simply said I don't mind doing it.

Interviewer: Interesting, can you expand on what the bot does in a project? Does it completely replace the project manager?

Participant: Well not completely, someone has to plan the project and coordinate the tasks and make sure the objective is reasonable etc. It doesn’t find us new clients so it only works internally, but it’s very valuable for us. It is a lot of help.

Interviewer: If I understand correctly, the AI becomes useful once the project is started, it cannot initiate a project or find new clients? So it is the human element after that point, but once a project starts then it becomes a vital team member, the reason that you have named it as well humanizes the chatbot?

Participant: It is always being refined, we are always having discussions about how often we are supposed to get notifications from the AI. Whether having every day telling us about yesterday is too much or too little, and we are often making changes and alterations. Because it is a “person” we joke about him every day. We “abuse” him and make jokes of him in the channel. But that's all users’ feedback, because it is a chatbot developed by someone we don't get angry at that someone.

I think, if it was just called the “chatbot” we would be angry at that someone who [developed it] but because it is a “person” we just abuse the bot. The focus is on the bot. The people listening to that and will get that feedback. We have emojis for the bot having a good day or a bad day and we just talk about him [the bot].

Interviewer: Does it help build a camaraderie team spirit?

Participant: Yes, it does. As I mentioned we also have a planning system where we have our profiles and CVs. We want to integrate this with the bot analysis. If we get all under one roof we have more data to work with and we can begin to cross reference. If somebody has not allocating hours for a particular project, we can then ask whether the system should allocate this person towards this project instead of doing it by hand. It is a ten minute job, but it is admin work that you do not want to bother doing when you have work to do.

Interviewer: How far does the trust for the bot go?

Participant: Well we can’t trust it having real conversations, it cannot be replaced in that way. We are humans after all, all the real serious or significant talks, like annual reviews and ore serious matters we sort out face to face.

Interviewer: What about the trust. In the bot is doing right, you said you “abuse” the bot if it does anything wrong?

Participant: Yes, we trust it to some degree, but accept that it is not always right.

Interviewer: Is there any plans to sell any of these products further?

Participant: There is some plans, we do have a team for that. Essentially they (government) would say that management should avoid confrontation around difficult things. Which would be defined as the job of management, essentially management is there to manage difficult conversations. The flip of that, it's forcing people to have conversations which general management don't have by breaking that initial barrier. On the flip of that, (government would say) “well that's just good management, you have to train people to be better managers to enable those conversations. Ultimately what you're doing is you are postponing human interaction” The question: is that harming later human interactions in another way? A second thing is around the hierarchy, that strikes me as very applicable in organizations where you have highly skilled, medium skilled and low skilled people. Having the equal hierarchy is difficult when you have many employees. How do you make them get to do their job? When you are essentially empowering them in certain ways to have a say over how they should be working, and how they should be operating.”

The last thing as well I think is particularly around that stress was very applicable for a digital environment where 90% of your work is operating on a laptop. But what about if you are in an organisation where 90% of your workforce are literally operating around the job, where there is literally personal one-on-one management? I would imagine if this was rolled out it, it would probably be applicable for central department where everybody is on a high level and where 90% of people's time is on computers. In terms of all organizational departments the first thing would be saying specifying some of these obstacles.

That is our organisation's biggest challenge, especially when it comes hiring people of different levels of expertise. We do have those challenges of making sure people are doing their jobs when they have all this trust. Which is why I think we have found that when you pay close attention to the culture, that you can have an impact on that rather than directly deal with the problem. It does work, I have seen it work. It works well within the company, but it has short falls, but then all solutions do. We are almost only designers, developers or researchers.

If you would propose anything to government, the first thing is that everyone thinks if it is applicable for all our government. No, but it could be applicable somewhere else. Just because it only serves one group well does not mean you should exclude it for everyone.

I use the analogy that "a Ferrari is not built to pull a caravan". Do not judge it by that criteria, if it is built to do something else. Only because it is applicable for a very small number of people it is valid for that purpose.

We get a lot of feedback of the reasons why people join our organisation, and it is because we did not have a hierarchy. "The fact that when we talk about we have a chatbot which is doing a lot of management they are sold." I do not believe this is because people have no intentions of working. We get this feedback, "Some people just do not like having someone else to tell them what to do, but if it is a bot it people get annoyed about the notifications, they do not seem to be annoyed for being asked." It is just that they have been bothered too much (by the notifications).

Interviewer: You don't see any challenges with asking your employees to share things in written form with a bot compared with talking face to face with a manager?

Participant: I think the reason why they made it anonymous from the start is because they want people to actually say how they feel. If we say that this is anonymous, that when you click a button you are going to be asked why, then you are not going to do that on a daily basis. You can opt out but also provide more information. It (being anonymous) seems to have a far greater effect.

Interviewer: Thanks for sharing that, we a have little time left, I really appreciate you taking the time for this. I'd like to ask about escalation, when a task is red or green, you mentioned before, what is the process then?

Participant: Well when a task is red means that it is not fully on time, if the bot is not getting through to the team member we have a person in each team to sort this out.

Interviewer: Is there any conflict then?

Participant: Not really, it usually means two things, either the hours are not reported or we need to staff up. That is not always possible so it's back to the planning and try to find ways to make it work or to extend the schedule. You mentioned escalation before, I prefer if people are honest and let me know as early as possible that they will not make a deadline. Sometimes things have gone way long before we hear anything, it then makes it more challenging if not impossible to fix it.

Interviewer: Interesting. Thank you for sharing your thoughts. Our time is now up. Again thanks for taking your time.

Participant: No problem, so what will become of this thing then?

Interviewer: Well basically the PhD I am doing is colleting the data, I hope to share the results when I am done.

Participant: Yes definitely, it sounds interesting. It is definitely in need to be research, that is for sure.

Session 2 March 2021

Interviewer: Some feedback have come up that I would like to check. When you work with data, do you aim to use historical or most recent project data?

Participant: So if I have to choose between historical and more recent data [project data generation], I rather feed the AI model with the data from the actual project [cognitive anchor to data].

If the AI has different data then the information given to me , which happens sometimes [misaligned goals and objectives], then if I find that something is not right I will sometimes not follow that AI output [override AI bias]. Since I also probably don't trust the AI in this case. When I decide to go for plan B, even if the AI is not suggesting so [override AI bias], I then mark some areas red [rework discovery].

Interviewer: Would you say this is a strong feedback?

Participant: I wouldn't say this is the strongest feedback, but in the middle [medium strength feedback], same regarding when it happens [medium term delay].

Interviewer: I understand, can you expand on that a bit more please?

Participant: There are other things that matter also and that have more impact on my decisions. I think this is important to notice, but doesn't have the strongest impact.

Interviewer: Okay thank you for that. Does this impact your planning or your confidence in the current plan?

Participant: Hmm, what do you mean with planning?

Interviewer: Let me clarify, does the type of data, if it's newly created data or historical data, does the type of data impact your ability to analyse?

Participant: Well if new data is showing more accurate results, I will most likely adapt to this. This will lead to that I am willing to change the project plan [confidence in original project plan] as new data is created [cognitive anchor to data].

Interviewer: Does this happen often?

Participant: Depends what you mean with often. We do it when it is necessary. We had a project before that showed a lot of different results. Nothing was working really, so we had to make changes. Changes that not everyone liked. But they were necessary.

Interviewer: Why did not everyone like the changes? Can you expand on this?

Participant: It interfered with their work and had invested resources in projects that had to be redirected. It happens all the time so it wasn't anything special with this specific situation. But it affects people differently.

Interviewer: This sounds like it is related to project escalation, you mentioned last time that you use a RAG system. I'd like to combine these topics, what in the data can make you and project managers not to take action when a project is escalation?

Participant: I've use the rag system in many projects. If I use an AI analysis and RAG it is a different layer of decision-making. A factor to not make changes to the project [escalation of commitment] is that the team still believes the project plan is viable [confidence in original project plan]. It is obvious that when the project is escalating, it is easier to not do anything at first [escalation of commitment], it takes usually more guts to interrupt the progress of the project [willingness to take corrective action].

Interviewer: So if I show you an example of a feedback loop it would be interesting to see if you agree with this example of not?

Participant: Okay yes show me I can have a look.

Interviewer: Here is an example of willingness to take corrective action and trust in AI affect each other and other variables influencing this as well.

Participant: Yes I can see, hmm this is interesting. I'd say this is accurate, but there could be other factors as well. We have complexity and I see you use the term rework, this is realised once after the RAG.

Interviewer: Would you say this affects your decision-making and it is representative of your process of making decisions?

Participant: I all depends on the situation. It's related to both willingness make correction [willingness to take corrective action] and the confidence in the plan [confidence in original project plan], it can take a long time to take action [willingness to take corrective action], since it is my first assumption [short term delay], and difficult to change [strong feedback] but when it happens [willingness to take corrective action] it will go fast.

Interviewer: Is there anything else you would like to add to this conversation?

Participant: At the moment no.

Session 3

Interviewer: Thank you for seeing me again. I would like to collect more data regarding the feedback loops I am developing.

Participant: Interesting to see what you have.

Interviewer: you say this causal flow is accurate in the context of project managers using AI for project control analysis. I will let you look at it first.

Participant: Hmm yes after looking at this I would say this is interesting. Maybe some terms I am not familiar with. What do you mean with the these names?

Interviewer: Thank you for asking. Absolutely, so rework is discovered and goes to rework to do, which increases project progress. This represents the ongoing progress of the project. It decreases original work to do and rework to do with to loops. It goes to error generation, undiscovered rework and back to rework. This forms another loop. Project progress increases project data generation and trust in AI based on new data is preferred

to use over historical data. It increases willingness to take corrective action and back to rework discovery. Any questions so far?

Participant: I see yes, well yes and no this is me as the project manager's decision process correct?

Interviewer: Yes that's correct. So trust in AI is reinforcing through the loop I mentioned last here. And it creates an increasing willingness to take corrective action [willingness to use AI]. But also reinforcing anchoring process to project data [anchoring to data]. This is through project data generation increases cognitive anchor to data which is the new generated data which decreases the belief in the project plan [confidence in original project plan]. Any questions here?

Participant: No not really, I would say this is interesting I may need to look at it more and get back to you if I have other questions.

Interviewer: Absolutely, the last chain is the increase of escalation of commitment here [share screen on the computer]. There are also two constant variables it's called, AI explainability and project uniqueness.

Participant: Okay yes I see.

Session 4

Interviewer: I know I have said it before, but I think this is the last session for my data collection and iterative validation of the feedback.

Participant: No problem, looking forward to see what you have.

Interviewer: This time it's not as many loops and not as big model as last time. Some similar names as last time, the difference is mainly the context of here the project manager is acting against the AI and is enforcing de-escalation. The PM believes something is wrong with the project while the AI is not indicating this. So this behaviour is found in override AI, with impact from uniqueness and explainability. It increases rework and reporting and project rework. It is a common representation of project work to have rework affected by error generation, with work to do affected by initial work and progress. The work ends up as completed. If I wait here, do you have any questions?

Participant: I understand, I look at it earlier and don't really have anything to comment on.

Interviewer: Okay, I'll just continue explaining. Project rework increases by default project overruns which increases misaligned information. This is critical for overriding AI. Different

information increases overriding AI but decreases trust in AI. The escalation link is presented here as well. You are free to comment on how representative this figure is.

Participant: It's an interesting view, based on the context I don't have much to comment on, I believe it is representative. Maybe I would've chosen different terminologies, it is a bit academic and maybe in reality I would talk in different terms.

Interviewer: I understand yes it is a bit academic. Do you have anything to add to this conversation?

Participant: No I may look at it again later and then might see if I still remember what it means and all the terms haha [laughing].

Interviewer: Yes please do.

P7

April 2020

Interviewer: Can you tell me about your background?

Participant: I started my career in IT, gained experience there to projects to switch IT systems. My project management experience is from the finance and bank industry. Became APM member at 2002, by then I was quite senior project manager in the IT department. Until then I was in software and infrastructure projects. Then I started to become involved with organisational projects, merge acquisitions, set ups in the IT department. I became a consultant and a contractor. Spent time on Wall Street to implement an investment management system. From there back to the UK and the bank industry and acquisitions. Been in banking in South America and the United States. Back to the UK and complex projects. Engaged with laying fibre network**.**

Interviewer: Can you explain your organisation's ambition with automation until 2030?

Participant: By 2030 no employee will be carrying out any manual tasks in their daily activities. Get to the point of every employee can add human value. All the mundane straight through processes are setup and automated by then (2030). We have platform called "Nomad" which has opened a lot for us as a company with automation. We have used it internally to automate manual processes, but also started to use it for developing products, externally as well. I have been involved with the APM during the last 10 years.

In our industry there is a level of governance required before you can onboard a customer and the customers have to prove through several steps their identity. Then you have to maintain that data integrally over the period of time when you maintain that relationship. In a bank it can be a customer opening a bank account procedure, in a telecom company it can be similar to the customer wants to order broadband or a landline or a mobile contract. The first thing that is needed is the customer to prove their identity and that can be very time consuming if you think about the different systems and the evolution of companies. To create something that will work across all departments and all different branches of an organisation that can cause some problems quite quickly.

These problems were acknowledged and our organisation decided to acquire a company with a Robotic Process Automation (RPA) product (Nomad). It takes about 10 to 15 minutes to set up a customer from step A to Z, setting them up in the system, setting them up a broadband or a new mobile contract. The issue is the hardware the customer need. The only bits where a human needs to be involved is when delivery of hardware is necessary or when a phone is collected at a

store. Everything else around provisioning of quite a few services has been automated fully. I talk a lot of banking but I say I'm in IT.

Interviewer: Can you explain if your product is based on AI or is it focusing on data?

Participant: The data is central in our system, and then the analysis or algorithms do the security check.

Interviewer: Okay I see. Do you see additional areas which could be automated?

Participant: Yes there are many. As an organisation we are looking for additional systems which can integrate with Nomad, that is the first requirement. Whether it is an Enterprise Resource Planning (ERP) system or a billing system it will integrate with nomad. Any manual steps that can be automated will be going forward. You will enter the data once, it could be a web-based screen once and it will then be used to fill in forms in other systems, create any documentation that need to be archived. For instance, a photo of a passport might be required to be kept over a period time, the period of time is all set up and (the photo) is automatically disposed at the end of that time unless it is required to be retained. All of those type of things are automated from start to finish.

Also automating the product side. Sims (sim card) products with IoT. Until now sims have been physical. That is moving away, sims are becoming integrated with the product.

If you integrate the technical possibilities with built-in sims in product and you integrate them with Nomad it becomes interesting. Check vending machines' firmware over IoT and via Nomad we can say "we want this X update version instead of Y version, if you find X version update it automatically." Through proactive management of the products get some benefits. A, it becomes a selling point "we proactively monitor the quality of the service and will proactively improve it before you can report any issues with it." And b, that reduces the amount of support and the service we have to build around the support to be able to offer that to international customers. A 24/7 help desk might not be required because we can reduce the number of issues that get raised by proactively managing firmware versions for instance. That becomes interesting.

Interviewer: Is this technology a common trend in your industry?

Participant: No we are pioneering in these areas at the moment so it is quite an interesting topic. There are other telecoms that are looking at this, but they haven't come as far in the development and other aspects. We are very appealing at the moment in terms of pioneering and creating that, it is effectively a niche market." This is why we have been able to grow the market share very quickly. Because of the new products we are picking up Chinese clients. The

fascination thing of this that the only limit of this is the imagination and the creativity to create the products. Once you know the platform and what it can do you can probably automate it.

Interviewer: What is the biggest challenge you face when selling this to our clients?

Participant: The people who signs the checks are not often technical. We have to meet the technical team to explain the products and services we offer. Those markets which have gone into IoT already have a mindset which is more open to this kind of creativity and they early adopt for example the finance industry. Other industries are looking for something that has been in place for at least two years before taking it onboard because they want to make sure there are no bugs and the systems are stable. They are looking for stability rather than pioneering functionality. In the market of IoT the buzz-words are new, creative and new products to break into markets themselves. There are lots of different areas where this is unfolding at the moment, so it is an exciting area.

Interviewer: Referring to the 3 Vs in big data. What is the volume of data you manage and are exposed to in projects?

Participant: When placing out fibre cables we used the we previous did not explore. There are systems that monitor the performance of network, such as IP networks, telecommunication network or mobile network. What there are not that many of is “quality of the experience” systems. That is where you proactively can gather data to then build network more proactively. We have installed some robotics prototypes on our network. These prototypes are proactively gathering information of the network.

With the fibre roll out we have fibre routers in every household with those we are able to gather information from the routers in the households, so we can tell the number of devices per household, whether an apple iPhone is performing better than an Samsung phone on our network. When you start to cross-reference that data you can start looking at statistics for instance “does the BBC iPlayer work better on an apple iPhone in certain areas. It becomes power in terms of what you can use the data for as a company. From a marketing perspective it is very good and very good from a network provider. We can manage the network proactively. There are a lot of other possibilities as well.

This approach and the use of our nomad platform got me thinking that there must be ways that we can plug some of the data into some of the projects as well. We have started to implement some automated PM processes on the nomad platform as well. We started on this a few months back, so still very new. We have taken the approach as if you place the data once you should not need to duplicate that data manually anywhere else. We are looking for a central repository and we have started to create this where data for project can be gathered once and once it is

approved it is baselined and from there you use the central repository reporting and status update, it could be a monthly report for you to report to your stakeholders and all that is collected form the central repository. These are ideas we have got after working with the nomad platform and some of the technical projects and seen how data has been gathered. We then thought "well we might as well use that for some of the project management as well."

Interviewer: Are you using this central repository today?

Participant: From a telecom perspective we gather 4 terabyte of data per day for our network management purposes. In terms of project management side of things, it is relatively small in terms of scale, we have 15–20 project managers who are centrally based, we have more in the organisation, but 15-20 centrally project managers centrally based. But with all the duplication that we are now already reducing, we can probably reduce that by two or three headcounts straight away. A lot time is spent report generating and filling out data forms required for approval processes in different part of the project life cycle. We have a gating system, when you get to gate two approval that is basically your business case, by then you should fully understand all of the planning definition. It is all put down in a business case and it presented to a portfolio progress group for approval. At that stage we have a baseline project and we use that business to collate all the data we need to then reuse at a later point in the project. We know we are already saving 15 hours a week just by having done a small amount of creative, central repository and utilise that during the course of the project life cycle. It is still a lot to be done but we have made a start effectively.

Interviewer: How do you utilise these hours that you save?

Participant: Absolutely, it has not been a reduction of head count and has been a reassignment of headcount in more interesting work. This is aligned with the ethos of the company. Every company want to reduce it costs, but we do not want to do that through reduction of head count. We do not believe we will be able to while we want to expand and grow, and we want to do that through automation where possible. The staff can then reassign to more "interesting" work. The staff has been freed-up to concentrate on the project management elements that can not be automated, the soft skill, holding workshops, chairing meetings, convincing stakeholders, whatever there is that they need to utilise the soft skills for they have been able to concentrate on that rather than having to sit down and duplicate the same data on a different form for a different purpose.

Interviewer: Do see any of the soft skills areas to be automate as well within a few years?

Participant: Fascinating question and fascinating topic, yes there is definitely more we can do. As people start to trust the technology and data provided by the technology more people will be

A more inclined to sign off and B there may be less requirement for a person to sign off because it could be a more automated process in itself. If are the boxes are ticked why can't it be automated? I guess the problem it creates is subjectivity and differences between projects. Every project I have done have been very different to previous projects. Does it take a level of experience and knowledge to figure out the best way forward? Big question to go forward. The intention with our organisation is we keep making inroads and plotting away and plucking away at new solutions and we will see where the journey takes us. That is hard to predict where we will be in five or ten years. For us, we definitely will have automated a large segment and we have been asked to estimate and we think we can probably get around 70% of a project manager today can be comfortably automated by 2030.

Interviewer: With the automated tools, do you still experience situations in complex projects where the amount of data is still overwhelming for a human?

Participant: I want to point out that we are targeting specific stages of the project life cycle. We are really targeting our delivery and execution stages. The point up until when the business case is created, it is probably from A to D of a project life cycle and the most subjective at the moment. That can be for many reasons, for example one project I am starting for a new ERP (enterprise resource planning) system. If you implement an enterprise level system within a multi, global, jurisdiction, currency type setup you have so many variables from day one to consider and so many constraints and guidelines to work within. For instance, a new RP (resource planning) system, how do start narrowing that down from day 1 and could that be automated? And yes, there are factors that could be because you can make certain decision based on black and white facts. For it is the black and white we can automate, in the grey areas the data is not always available for instance. You have to gather information/data in order to formulate decisions around a project, because the quick growth in our company the speed of integration of companies we have acquired to be working on centralised platforms within the larger group has been slow. When we come to implement a new central platform we do not just replace a previous platform, we have to talk to four or five different jurisdiction what they are using now and their requirements and make sure that is taken into account in an architecture phase and ensure their requirements can be met form the product and solution we will be implementing. This is where there are many factors and grey areas, "okay your start to automate some of that stuff", but all of might not be black and white for instance we could go and talk to a jurisdiction about a certain change but we cannot finalised yet (documented) because of market speculation reasons, for now we then include them in the scope but need to "drop" them at a certain point. There are a lot a variables that can be introduced that can make this an complex equation quickly. We concentrate on execution and delivery when the project is baselined

because getting it to a point where it is baselined because it appears at the moment to have the most variables.

Interviewer: Do you collect external data to analyse?

Participant: We are a group of companies that sell external products so we have to look to external markets for our data as much as we look internally. And we have to rely on that data so it is a key factor for us as well.

Interviewer: Is that something you have automated?

Participant: To some extent yes, but then you start to rely on other peoples' data and then you start questioning if there is an element of trust there, how reliable is the data. Can the data always be provided in a timely fashion when your system needs it. What happens if there are alters, and there are a thousands questions that arise. When you have internal data you can control the quality and maintenance the data. When it is external you often only have a contract in place to actually enforce what an external company or party might be telling you and you have to rely on them in fact to deliver. In my experiences it is less reliable.

Interviewer: You mentioned the project life cycle, when in the project life cycle do you receive most data?

Participant: Good question, that is before the execution and implementation. That is where a lot of analysis is taking place at the moment with typically teams of analysts in companies in different areas. It is interesting that the same team of analysts are working within our organisation and there are synergies there because they are also helping with the implementation of the automation of processes within our Nomad platform. We have teams of people who carry out manual analyses and also implementing automated process and are being asked to think creatively al the time about improvements going forward so that is how we can improve in those areas.

Interviewer: Do you use previous projects when planning future projects?

Participant: We do to an extent; we are a pioneering company. There are not always previous projects we can utilise data from. Rolling out a fibre network has not been done but there are instances during the implementation that has been done before but not the whole process. We can use some data out there, whether it is the right data (appropriate data) is a different case. It is limited because the type of stuff we do, but when we do more traditional projects, we will go back to data that has been previously gathered, lessons learned etc and **we recycle that and use that the best we can.**

Interviewer: Can you build on the velocity you receive data? Is it in a "live" manner or via a "gate based" process?

Participant: Very good question. If you were going to start a company today and design technical infrastructure to cope with what you knew, the business plan the technical infrastructure etc. That would be a lot easier with a group of companies that keep acquire new companies and tries to integrate the best you can. We are of the latter model (gate process), because of that we do face problems when managing data. We face problems to unify our architecture and simplifying our architecture as opposed to managing from the top down and coming up with a "straight through process based" architecture that fits with all the companies that we suddenly acquire. IN some areas it is not a problem because we have scale and experience of running the operation, in other areas where we make acquisition and integrate new companies, the data we acquire in that process can be problematic. Then we end up bolting on as opposed to managing top down of our infrastructure network.

Interviewer: Would you say that you use big data in your projects today?

Participant: Yes definitely.

Interviewer: Have you always done that?

Participant: It has been done for 10 years. Within the telecom business it has been done since voice over IP has been implemented. Since it has grown and more technology grown from that, the more data has been available.

Interviewer: Is there anything you want to add to this conversation?

Participant: Yes and no, it's an interesting topic. But I am happy to answer more of your questions.

Session 2

Interviewer: Thank you for this so far. So I have a few question I would like to tik off. How would you define your AI? Is it machine learning or more decision tree?

Participant: It's basically a decision tree.

Interviewer: What's your experience with AI and machine learning?

Participant: Good question, I have variety of experience, but focus is on data. Not much coding in machine learning myself.

Interviewer: Is the AI involved in project control?

Participant: Yes and not, it is used for everything. All different purposes. If we need data for specific tasks it can do so.

Interviewer: How do you define project control?

Participant: Well any time when there is a need of assurance and security of questions. We may call it differently but control is a hug thing. We don't isolate it for this.

Interviewer: Do you use your products for other project phases too?

Participant: Yes certainly, we use it for all phases and other tasks. Not only projects. Our major initiatives will need this too. All possible resources will be used when possible. Does that answer you question?

Interviewer: Yes it does, feel free to answer in your own words. Another part of my research is escalation, what do you do when the data shows something bad or something isn't the way it should?

Participant: We have to go through with it. The system is there for a reason. If we do something else it becomes an issue an you will have your manager coming up to you.

Interviewer: So when you use the system it is not a decision-process for yourself? I mean you don't have a choice to take decision A or B.

Participant: This we do, it is not a single decision, it is still many decision that need to be made. We have find the best path forward. We just can't refuse it.

Interviewer: What behaviour do you recognise during such escalation?

Participant: Well it depends, this is when all the active roles come in, usually it is not a single person, the RPA may see something or the system may indicate a user does not have all services ready. We have to go through the process of finding the right person and the right solution. It can take long or go fast. So when you say behaviour it is a bit confusing.

Interviewer: I understand. You answer honestly and you answered my question fair. I have all that I need for now. Thanks again for this quick chat.

Participant: No problem, good luck with it.

P8 January 2020

Interviewer: What is your experience in project management?

Participant: I have 35 years of experience. I have SAP development ERP (enterprise resource planning) from Germany. It does everything for a company, HR, sales etc. I did one SAP deployment in Canada, one in the United States and one in South of England. All under budget. I became a contractor, IT contracting with a few different organisations. I have been teaching project management for the last ten years. I currently teach cost and finances, we have post grad here where students must have a undergraduate degree and I teach that program. It offers me the opportunity to work with college resources and do research there. I am working on a few tools, they are predictor tools and are ported to a cloud platform. This way people can set up an account and just log in and use it. I am also working on the virtual assistant. Let me show you an examples.

“Alexa is there any training the scope document?”

“Yes, there is training. 5 people are identify for 1 week of training. Would you like more detail?”

Of this kind of technology there is one in Germany called PM Otto and one in the states. They don’t use it for project management, they will take all the company policies and procedures and put them in an application that you can access by a personal assistant (chatbot, Alexa, Siri etc). Everyone in the organisation have access to be able to use their smart phone to access policies and procedures.

The concept would be instead of loading policies and procedures you would load project documents. I am now working on the logic behind it, so this is project management logic. Let me show you:

“Alexa, there are three tasks this week. Can I move them to next week?”

Alexa “The task schedule is not on the critical path, however one of the tasks have an identified risk base on the risk register. Should I contact the risk owner and ask her to contact you?”

That is trying to put project management logic behind the questions you are asking No one has done that yet. If you understand project management, what tool understands what a critical path is? Other than MS projects etc and looking at the critical path but there is not interpretation for it. My team is working on, in terms on logic, is tying everything together into a holistic solution. You do not only look at resources or at a task you look at everything associated with

that resource or task. In that sense you get an overall perspective and you are able to make a better decision.

Interviewer: Sounds very interesting. How would you define AI?

Participant: It is exciting I'll be working on this for 3 years. I would define it as making predictions we human can't fo. And with my it background I thought maybe a better start looking into this way I think so I started to do research started to learn Python not sure if you are familiar with python what is the most common language for coding and neural networks, AI tools machine learning tools basically. I started learning that, Looked at data mining data Analytics I don't have the depth. I call myself in mediocre programmer but I look at it from my perspective of the issue of project management now is: I think a lot of people, no one knows what it does and for people like myself who understand the technical background of it is coming up with these creative ideas with how we use it, and that what is I'm working on right now. There is another book I'm reading now it's called genetic algorithms and it is how to combine machine learning with computations and mutations on your coding language and looking into how I can use that into project decision-making as well.

Interviewer: I don't want to change the subject but I need to give you some context to the research. So I have a master in project management. I did a master dissertation in this area and I am now doing a PhD in the same area. Now I can see you also with the video can you see my screen?

Participant: Yes I can, sorry for interrupting but do you know what's happening outside my window it's snowing.

Interviewer: Haha that's great. Today I am involved in this research project while writing my literature review.

Participant: There is not a lot literature on this AI in project management.

Interviewer: Yes that is the challenge. The definition of AI is always changing and it is a choice of including expert system and so on. If we go back 20 years we would have seen a different definition.

Participant: I don't mean to interrupt you but just as a side note Project management institute PMI the global Association. So what I did I took some of my ideas for developing. Because I an "applied guy", I like the price to collapse I want to figure out how to make it happen and what I did if that I took some of my ideas Applied for a grant and I was talking to the vice president of the PMI and he said oh this is fantastic apply for this Grant for help you with your research so I applied for the Grant they rejected me do you know why they said well first of all is to practical...

Interviewer: Mhm...

(exchange of surprised face expression)

Participant: I know now... And second of all they said we don't believe there is any academic research that has any models and you can improve on... So basically they told me there is nothing there you can improve so there's nothing there so you know so I went back to the guy who review this and he said “yes that's what's happens sometimes”... When you say you're having some problems with finding stuff I can agree to a certain extent you have to be careful because things like expert systems is written completely different to machine learning code. In my second book I talk about the self-driving Project. That is the comparison with the self-driving vehicle the self-driving car. What I talk about is the self-driving vehicle and how the self-driving project would work. I do that analogy to talk about all the decisions that has to be made or that an algorithm could make through the project. When you talk about expert systems they are written in a different way they are written in hardcoded logic where as machine learning what you doing if you're using the data to do some statistical analysis and based on that data you're making a decision you don't make a decision based on an algorithm telling you what the logic is.

Interviewer: Thank you for that analogy. I recognize it from you your book.

Participant: Yes maybe I have included it there. In the second book I have a whole chapter on it.

Interviewer: The same analogy has come up for me trying to find similar problems in elsewhere. There are no simple projects where you can predict everything if not asked driving in a tunnel. Where everything is predictable and you have no external variables. Projects operate in a complex world. What is your thoughts on that?

Participant: Yes so projects have an objective. All the rules are your project management logic and the car is driving along you basically use whenever I risk occur and you use the risk management mitigation plan. The issue is in projects a lot of things come up and we say what's the best decision to make and if your project manager right now people make decisions based on their intuition or their experience with their historical knowledge well guess what a machine learning tool can make a better decision and the reason is because she has learning tools that should have more knowledge more experience if you think about it one of my examples I use in my book for MRI and x-rays the way they do x-ray scans where they feeding in an AI to and it determines whether it is a positive or negative. The xray doesn't only look at the X-rays from one hospital they can look at the X-rays that's been taken from every hospital all across Canada and maybe every Hospital across North America or every x-ray are Cross North America for the past 15 years you see how much the data that is so now if we use that analogy for project manager project managers can't compete they don't have the debt of knowledge or experience so if we do

it right course the best big thing is today that how do you get the data where do we require the data from? That's the biggest issue for project management if we did then these tools would be make much better decisions.

(pause in interview)

Interviewer: My research question is in social science and my research is through qualitative interviews with practitioners. If you are able to answer some of my specific questions?

Participant: Absolutely. I am semi-retired and I do whatever I want I do research into AI and I teach project management as I love it and I am developing a little bit of a collaborative group I do want to mention a couple of people who should be in contact with.

Interviewer: I ask questions around data and the perception of big data among project managers.

Participant: Yes, If you want to record anything Please go ahead and one of the things I've talked about within my collaborative group if that we have the small group that it's working on AI tools and what we are trying to do is to make some collaboration because we really all have the same goals to really improve their success of projects and show that AI tools can be successfully implemented to increase the success rate of projects so that's what we're trying to do and no one else I'm really working on that if you look at Microsoft projects they might do some predictive Analytics but that's not really project management AI.

Interviewer: I have come across predictive analytics what would you say if the difference between AI and predictive analytics?

Participant: Predictive Analytics only does the analysis side. Let me give you an example I may have used this in the book but I do use it when I talk. I talked about the mistake you may be making so when you use Jira Shearer looks at resource usage. It takes all this data as people are completing tasks and let's say they have two different people on different tasks and placed on their work performance name might say “we have done the analytics here is what you need to do”. “Take George off the fifth task and replace him with Mary and take Ramesh of this task and replace him with Andy” and now your project with will succeed. It's analytical and it's prescriptive but very simplistic basic analytics. My claim is what about risks what about quality it doesn't say anything about that what about if you deliberately put that person on the task in

order to reduce the risks and what if you deliberately do a mash on this other task he delivers higher quality? These predictive analytic tools are just stupid data analysis. The difference is machine learning takes the historical information, similar of a has to incorporate all of the data and all of the experience of the project to make a good decision rather to say "oh yeah this person is too slow, let's have another person to do this project." We don't really need AI to do that right?

Interviewer: Ok so how would you define predictive analytics is nothing about cross-referencing in data?

Participant: It is in early part of AI, People talk about data mining. I have a client I'm working with now they are building power plants if I can give some consulting advice. My first advice was do some data mining look at your big data and maybe you can find some correlations in the data. So that is the first step that is not a i yet but it is to basics and it serves a number of purposes and the first purpose is to make sure you have structured data what happened was after my first call with them. I said ok do you want another call? Well no, we have some technical guys to go through or data. Well guess what? Yes they did not have structured project data. If you think about where is your project data? Maybe we have a word document? Maybe we'll have our scope document in word? Maybe we have our quality data captured, and our metrics is in an Excel sheet? And maybe we have our project plan in Ms Project? Now we have to find a way for an AI tool to pull all this data to a common repository or at least be able to access it in a way that every field has a readable value. When I talk to people, the first step on the road map. If you are doing a strategy, the first step is the big data thing you are talking about. It is data wrangling, getting the data in a structured format. And in a project management perspective it's a mess, it's all over the place.

Interviewer: I have come across a company which used a chat bot as managers, and they have removed the hierarchy. Their next step for them is to use their project management data and not only simple administrative tasks.

Participant: Yes, hey if you can order a pizza online you can have a manager online. So In my research that I have come across there was a survey where employees preferred a virtual assistant rather than their current project project manager.

Interviewer: I keep come across the human element in my research. I believe there are different views of what is important within the human element. May I ask further question today or should me book a future call for this purpose? (We did not have an interview prior to the introductory chat)

Participant: Please go for it.

Interviewer: From your experience, regarding the volume of data available today what kind of data have you been exposed to?

Participant: I would say I guess for the SAP projects, mainly the project involved around the project schedule so the volume of data was mainly kept inside a scheduling tool. Because that would have resources, tasks. In my experience that is where the majority of volume of the data resigns. The other volume of data form has been in the finance area. The second pillar, after the scheduling, is the finance side (of projects). How we track spending against the project (code as assurance?). This was a one year project SAP project. In software deployment you have to it quicker, because things change too much. So how do you track expenses? So that volume of project data would be basically how budget, our change orders, our invoices, expenditures against tasks. So that would be the second largest pillar, and that would be in a software too, some kind of database normally. And the third pillar would be within the pm triangle. Scope, time, costs. The scope documents, The scope document include the project charter, the objectives, the power points slides. That would be the third pillar of volume. When I consider the three triangles, I put risks in with scope. So when we have the scope documents we list all the risks as well. In terms of quality, I put that in the schedule, your tasks should have built in quality. I try to tie in the 10 knowledge areas. Communications plan would be pretty low of volume data, but it would be in powerpoint data you sent via emails and meetings. So that is the hierarchy of volume of data in my experience.

Interviewer: If we look a few years back, could you utilise previous data from historical data?

Participant: In my experience no. Because the organisations did not keep a lot of data, we kept data on a server, a sharepoint server but it would be extremely difficult to access the data. And even so there was not a lot of data. “In terms of big data there are a lot of things missing. For projects. The missing data is the decisions you make as the project progresses” (code as project execution). For example if you are working on the schedule and you want to do some fast tracking of schedule compression, that decision does not really appear in the schedule. You make the decision and it (the schedule) changes based on your decision. But how you arrived at that decision and what the decision was, and whether it was successful or not does not appear anywhere in the data. And that is important because machine learning use supervised learning. Supervised learning needs to be labeled (structured), same thing for issues and problems. You have an issue log. You have to have an action plan to resolve it and you need to say somehow whether that resolution was successful or not and that is always missing. That data always seems to be missing in projects. From that perspective, most projects have missing data. The people who have the most data and most data history in my opinion is governments. I know some governments have tons of data, because they are governed by institutions which manage

finances (on a national level). There is a government department that funds everybody else. In that funding they dictate the documents and the data you need to run your project. What happens is once the department completes that project they get audited, so they must have that data. So from my opinion, governments have the most data. Some large organisations might as well, like the power plant installation company I looked at. But a lot of organisations don't understand the value of project data. They understand if they are dealing with customers, boy o boy, you understand the value of data but organisation don't understand the value of project data.

Interviewer: So if I understood you correctly, it is during the execution phase where the documentation of data should improve?

Participant: I believe so, absolutely.

Interviewer: What about project control, is this an area for AI and data?

Participant: Definitely, project control utilises data all the time, I have been in this situation myself.

Interviewer: If I may I ask about data sets, have you been involved in projects with different datasets that you have been able to use?

Participant: That is a good question, let me think about that…

Interviewer: The data you have received, has it been straight forward? Have you been able to analyse the data points you have been exposed to? Has the variety of data been overwhelming for you to make a decision?

Participant: I think it is the opposite, I think it is the lack of data. I did a project for an association, and of course the first thing that happened was they were migrating to a new system. With a large amount of registers. They were moving from a 30 years old system to Microsoft Dynamics and the first problem they had was the data in the old system was a mess. Again we get back to structure data and data mining. It was such a mess, simple things like data fields had different terms. From a data perspective how do you manage that? In terms of the project it was a mess due to other consultants doing the configuration. This group did not gather the data properly, the resources were not managed properly. But you would never get the full information from the configuration group. Terrible communication, they did not want to tell you things, they wanted to keep things to themselves. From that perspective was lack of data not the variety of data. The data itself, you know we have a risk plan, we have a schedule, we have a scope statement we have requirement statement. The document variety of a project tends to be

very similar. Everybody will have the same types of documents, but the variety of formats can be different. For me the biggest issue was the lack of data.

Interviewer: In that sense I am referring to different format of data.

Participant: Yea, different formats of data. Basically different project scheduling document and they don't even capture the same things in the same way. There is no standardisation across project management. PMI tries to do it, with PMBOk bit nobody follows it.

Interviewer: You mention in your book, if you are able to capture live data you adapt the project accordingly. Have you had that experience? Or have collected data in a gate process?

Participant: Yea it has always been in a gate process. The only thing that capture live streaming data I suppose is tools I talked about when somebody is working on something and when they do reporting.

Interviewer: As a finishing question. My research sees projects focus mainly on internal project data. Have you experienced using external data in projects?

Participant: The answer is first of all from my experience, no organisations don't do it. They do it if they have a decision (strategic) to make, and that is the only time they look at it. For example, we have to hire somebody, a project coordinator, what is the availability? Then they go to look at something external but generally no they don't. Should they do it? Absolutely. I think it is a mistake that they don't do it. If they look at the predictor tool, I am not sure how far down I go in the predictor tool in my first book, in my second book I go a lot more depth. I talk about the predictor tool to be used in real time. In real time, as the project keeps progressing, you continue to use the predictor tool and the data is not just historical data but also internal and external data. I talk about the project environment and the project environment means that when you are making project decisions the internal environment is policies and procedures of the organisations may it is priorities within the organisation or resources it can be anything internal. And then there is the external environment where projects don't consider right now. I guess what people would ask me about this "well yea but how can you predict the future?", because I am saying no only the external environment not but the external environment two years from now. S the duration of the project environment needs to be taken into consideration. Much like a self driving car, the self driving car using radar to say if the road is clear ahead of me? (radar analogy for the external project environment?). Now with the project environment this means things like, what's is the exchange rate, what is the inflation rate, a lot these things are predictive. And if you look at some of these things like inflation rate and you are in the UK. They will tell you the exchange rate will be in two years from now. Maybe it will be off slightly, but

it will be pretty close. And there is a lot of things that can be easily predicted, the environment except for Brexit haha [laughing].

Things like resources, utilisation, salaries, organisation growth, competitors, things like. In an external environment you can predict rates, labour rates, things like internet rates, utility rates, inflation, exchange rate, all those fairly predictable within two years. When an organisation creates a business case they need to include them. If they included them in a business case why are they not continued to be tracked? I think it is a mistake that organisations don't use it. Again another criticism would be how valuable is it?

Interviewer: Thinking in a project portfolio or programme environment. Is it more common to use external data in that environment?

Participant: It is till not enough. I think it is more, but I still don't think it is enough.

Interviewer: To build on that. My research will include causal loops. Would the external environment be able to be included in a this context model?

Participant: I think it is a good opportunity for you, but you need to be careful with how much you emphasise on that. It may not be of much value for the project environment. The other thing you need to do, I will give you some advice. From an academic perspective, but I am a practical guy. What is happening in the academic world is people are building models based on logic or history or research. Those models, buy the time they are published they are obsolete. Because the world of technology is moving too quickly. But if you incorporate a machine learning tool into your model then the model will not be obsolete, because ML tool takes data and it continues to take data, tomorrow it takes tomorrow's data and so on. Once you have the ML algorithm, and included it can continue to take data as time moves on. What we are finding is that models that are built on ML tools are more effective over time than these academic models that say for example, here is how risks should be managed in a project. I don't really care what the model says, give me a ML tool that has all the data right now and based on all the past experience it will give you a better decision.

If your models are based on the input of data, as long as it is not static data, it has to be updated on a continuous basis. That brings us back to the real time data issue. The live streaming data, the most important about real time data we have to update these models, we can't have a model, an algorithm based on data and two years later be using the same model and the same data. It has to be based on new data. It may not have to be live streaming data but it has the velocity is important to supervised learning. If you don't update a model on regular basis it will become outdated, not necessarily obsolete but it will lead to bad decisions and decisions based on data that is not current.

ML tools are not applied to project management. There needs to be people who understand how these things work. Understand project management and then figure out a way to combine the two (PM and ML). I am not necessarily trying to build a bunch of tools, I am trying to figure out how to combine the general stuff with issues I see in projects.

Interviewer: What about AI for project escalation?

Participant: This is basically what we are doing with risk documents, they tell us when things are wrong. It should be done more on this. We need to get the data in order for the system to tell us what is wrong and how we can fix it.

Interviewer: I will look more into this. I have very much useful thoughts to develop. Is there anything you want to add to this conversation?

Participant: I think based on what is happening in current projects and how they are managed and the methodology, doesn't really allow for it. People say it doesn't make any difference. But once you put in AI tools and predictor tools, I think then it will be a bigger factor. And also you can include them and add data at no cost. These things are not difficult to find, it is not that you have to pay for the data. Everything is available on the internet. If you want to know what the inflation rate will be in the UK three years from now? Google it, hehe. It will be there and think of the government documents, they publish all sort of stuff.

P9

Interviewer: From our prevoious correspondence I understand you work within predictive analytics

Participant: Yes it is a very exiting area to work for. We are working with AI and machine learning in different dimensions.

Interviewer:Can you give me some backgound to your role and how your general expereince of project management and data?

Participant: Yes the predicitive analytic team itself is fairly new within the organisation, certainly within a delivery perspective. We were created beginning of 2019. As a wide spread delivery assurance offering team and delivery assurance team. And to look at programmes across the group. And were at that time targeting large investment projects so they were inline with big investment projects. The predictive team sprung up in order to guide the overarching delviery assurance team and use matrix and objective way of thinking. And to look at where we should really be targeting projects and investment spends. That is the team itself.

My own expereince, I have been in the projec management PM world for eleven – twelve years. I have hade muriads of roles from user accepteance test, project management, programme manager office, business analyst. So yeah a few roles throughout the project itself. My team is primarily of data scientist and data engineers and we have data jounalists as well, and I bring a lot of the business knowledge, I have been in the organisation for 15-16 years so I bring some business logic and how we do business within the organisations. And the team work with me to build models to support we can track the data that sists within those projects.

Interviewer:Do you have the most project management expereince in your team?

Participant: Yes, I am. I am very much a business background. I have worked not only in project management environement but also Business Analytics and fraud operations. I have that broad experience across the organisation in terms how things should be run and project management as well. Very close to the way project managers actually work, in previous roles I have sat in what we call a central management office, defining processes and the life cycles of a project and what artefacts projects should be. Creating how they should plan and risk mangement and all that good stuff. I sat in that role as well so that expereince mixed mith the data scientist can do with the data. And where the data outputs we get, that is where the predicitive team comes in and how we use that sort of cross sectional skills and ideally make best decisions and things and better focusing of our time and resources.

Interviewer:Okay thank you for that. Sounds intereting to me to mix the project management role and data scientist role.

Participant: Yes it seems to be working quite well, hehe [laughing].

Interviewer:May I ask about the predivitve analytic domain. I hear about different terminologies and I want to have a clear picture. Do you use any machine learning model?

Participant: We are provided the data from others. In the group there are numbers of different tools project managers have to use as part of their projects. There is a central project management tool to log things and milestones. There is another tool to log other lower level of details surrounding testing. Then there is another tool that looks at day to day activity lists on a lower level and detail level. All this information we consume within our world and we have two models that we built. One them is a model that takes all that data and applies an objective view to that data, what we mean about that is that we are very consious about being project managers. Project managers will rag their projects whether or not their projects are red, amber or green. That is very subjective and a rough guide of how the project is running. Green is good, red is bad and amber in the middle.

What we find as an organisation, we do have significance investiment spending and a significant volume of projects we look at on a day to day basis. There is a lot of projects that sit in an amber space. We don't know if they sit nearer to the green or the red end of the spectrum. Part of the work that we do is objectively take all of the data that is relevant to those projects, we run it through an machine intelligence model that is built upon the history of the infomation as well. Some of the tools we use we have been using for a few years and we have a very rich history of projects and programme information and we look at this. This is where a data scientist can answer better. But per saying the underling data actully suggests you have a toxic mix of these types of risks, plus these issues, plus these dependiencies, plus these change requests, plus the stage you are in and the complexity, actually where we see that historically the commbination on other projects that is implied that there is a fracutred delivery which you want to do somehting about. So the score will be below in that instance if the rag is green for that prject that prompts for a conversationa and discussion why the score we provide is low and why the rag is different. To be honest sometines we run into quality issues and the project managers just hasn't updated the score systems for a while. So things are running smoothly but we don't have the data that backs that up. That is definelty a challenge we run into, but yea that is really one of the models we look at. Very much there is other machine learning constantly evolving, we had to train the model a bit to do that, it uses a rich history of infomration and it is evolvoing itself aswell to make sure it is comparing the correct data as the organisation is evolving.

Interviewer:I am not very familiar with the rag. Can you clarify that? Is it similar to a status update?

Participant: Yea, I don't know how industry wide it is. But basically what we ask is the project manager to articulate very simply where the project is as a traffic light status. Green is good, red not so good and amber somewhere in the middle. We get a lot of people saying "we are amber", which is not very helpful. Seeing we don't know where they are. We almost provide a more granular objective view of the world. Because the rag is very subjective.

The other thing we do. The second model is the predictive bit, we take all that infomration and rich history and the sector we created and apply that to a predictive model so we look at six weeks in advance and trying to predict where the score will be in six weeks and if the score is dropping to certain amount there will be an increased risk delivery on that project so therefore we want to do something about it today in order to mitigate a risk that may meterialise or other conserns on the project so again that is very much predicitve model and again, that is continously learning and is relying on the quality of the data that goes into the tools.

Interviewer: I want to ask two questions to follow, regarding the data and also I have come across people convincing others their prediction models are correct. Do you come across PMs who challenge your predictions, based on their own knowledge or experience, which may no be tangible and may be tacit knowledge and so on. What is your experience of this?

Participant: Very good question. The team has been just under a year. And yes it a real challenge to us to try and convay some of the outputs of our models, because alo of people see a score and they know its been built trough a model that isn't in the backgorund that they don't have initmate access to because they don't nessesary understand how it has been built and therefore there is interpretation across the organisation, it feels like black box technology and should it be trusted. As a team we spent the last few months making sure we are fairly transparent where we can be to people so they understand it is not wisardy and witch craft.

you know it is curious for a mathematical model it is all based on the data they provide as a project team and the tools they input to, so that it is not something we have made up. Another point is we also keep irriterating the model is fairly young, around a year, we still actively engage with the pms "this is your score, rag and the predictions" do you agrree with this information? In all honestly, it is an emotive subjective to talk about their project, they want to be in control of everything and they don't want to admit they do not know what will happen 6 weeks into the future. So it can get emotive, but because the way we create the model and the way we tested it, we were able to prove before we relased the model, that projects were sampling, so we produced a score over time and been able to show that infomration for PMs makes it more

trusted tool because they were able to how we come to our conclusion. One of the other challenges that we sometimes have, in the predictive model, it will predict a the downturn of the score, the resons behind the downturn are not easily confeable to some people. So it will pick up on fairly minor points that as a human you would probably dismiss and some of them can be almost to a point to confusing to a human of why it (the project) is showing some distress. So we have some challenges in terms of how we sometimes translate the output of the model into something that can actaully be used. That is a journey we are still on.

Interviewer: Are you able to give me an example of such a situation which couse this confusion?

Participant: Yes so a really good example is the predictive model will say there is a higher chance of a project score reducing in the 6 week period if it includes the words “impact on customer” in its latest progress report. Now, organisation we have a lot of projects that do impact customers and the challenge is that if the words are in there the model has sort of identified past projects that have come into delivery risk have had that as a trend or attribute in thier project status report. Being an indicator that something has happened, the problem with that phrasing of word, is one textual and the other one is that it can be prefixed by the word “no” or not prefixed by anything and it still has the the same impact. Trying to explain that to somebody is very hard, we are amost saying “the model has picked up this phrase within your progress report which is indicative to that the project has been in distress” but as a PM they would turn around and say they don’t have an impact on customer or they do have an impact on customers why are you telling me this, what relevance does this have to me on a day to day basis. And we cant explain that because unfortunatly it is the way the model picks up details. So we are at a point where we wouldn’t rely that infomration to somebody. And we know the model is working because we can see projects detererailing over time when we have been testing. And you know they will have that phrase in the progress report but trying to explaint hat to somebody is very hard because it almost doesn’t mean anything.

It is quite exciting for us, as a team with data scientist it is great they are able to track that sort of data and bring this to life through the model but yet trying to reply that the business scenario people wh don’t have any machineintelligence knowledge is quite hard and that is one of our challenges. So that is a good example of where we are giong thorugh our jounrey and how we almost provide value out of our models.

Interviewer: Thank you for that example. Would you say there is a problem with data coming in from the PMs? Is the data you receive unstrucutred in a way that causes problems for the models or is it a question of training the model for a longer time?

Participant: It is sort of a combination based of the data sorts itself, we have some really established PM systems within the organsiations which have a very strucutre way of inputing data which is great because then it is consistent across projects. And then we have another couple of tools which are not so much hehe. So they are very challenging in terms of the data and they are not consistent across projects and you know we have a lot of projects so having incositency doesn't help us so we do run into those sorts of challenges. The particular I was indicating starts as a project status report so we do a bit of text analysis on that and there is no standard for that report, it can be a handful of words or other different forms. So we do run into such challenges.

Interviewer: I would like to ask questions regarding data from PMs, do you think this volume of data is sufficent and manageable or is it too little or too much, what are your thoughts there?

Participant: Again, it depends on the systems we are using. More established systems I think we have just the right amount of data. You know, we are in a good state to do things. One of the other systems which are more flexible from a user point of view, to use that wording (indicating user freedom it is not good for him and his team) so it is almost like the issue is an issue management system so it has a lot of data that we don't necessary don't need ot process but it creates a quite a bit of noise in terms of whether we need to inlcude or exlude in our model so that is a challenge. I would say it is dependent. Overall I would say we have too much data, and sometimes it can be hard to establish what do we need to look at (better data awarenss leads to a stonger data culture within the organisation). And again the systems themselves they have various levels of dictionaire assigned to them, some are well populated with updates on a regular basis. You know with some regularity and you where the documentation is and if we need to run APIs (application program interface) into them, where as other tools are not quite as forthcoming with their data dictionaires ot they don't have APIs at all and it is a bit harder therefore to make sure we are using the latest set of measurment of attributes for each projects. So overall I would say we have too much data available, then it is shifting though that to work out what data is relevant.

Interviewer: Do you think the project managers who you receive data from share this view that there is too much data?

Participant: I think it is a bit of both, from a project perspective, the complection of data so in various systems they would probably prefer a sleeker way of doing things, using less sytems or having more efficent way to enter data to those systems. I think the data avaialble to them in terms of what ever they are doing we got quite a mature of group handle analytics team which work with the vision across all departments. Which are able to provide them almost with an

internal consultancy and the group handle analytics team will pre-process it for the projects themselves so they make sure they are looking at the information. The same question may refeer differently to different people. PMs do actually do their role to have the data to run ther projects because they request it specifically, me and my team are loking around all data across all projects probable have too much. Project managers themselves actually populating data they probably think some of it is a bit pointless.

Interviewer: You seem to have a good model of how to gather data from PMs and they return it in more strucutred form. Is this a common way to work within the finanical industry or is it new for your organisation and the industry?

Participant: I think it is more common now across the indsutry. I say I am in the IT business of a financial organisation. I have been working here for about 15 years, and 11 -12 years within PM. We definatley did not have the richness of data, we had a rich set of data but the actual playback of it and the visualisation of it was nowhere where near of what it looks like today. And it feels like we are making decision are more data focues, the data is having this thing, so lets adapt ourselves to this because the data is telling us, not necessarily (only) market research, (but) the data is showing us how things should be done differently. In terms of the interactions in between different systmes as well, each system we used to have, like PM tools, they have their own in built dashboards, but as a PM you needed to go into each tool to gain information or create power points, whereas now we have a centralised reporting service which will feed a lot of our data into, espically on project leveland we can create a view acorss different tools and differet projects and departments, so it is like a one stop shop for project visaulisation or reporting that has been around for 18 months or so.

Interviewer: Is your team similar to a PMO in some sense?

Participant: It is probably supportive of PMO, beceasue of what we see we can target a their interactions in projects in a different way. Previously when I have worked in PMOs before and a lot of the role is about risk and issues management. And a lot of it would be trawling though data through systems or creating reports or playing with excel whereas again we can now stop that happening manually and provide an insight through the model we have created. And therefore direct their attention to things, risks that may become an issue. Almost supporting them to have more value add, intead of creating a reports, excel documents and powerpoints, we can focus their attention on more value added activities. Which they prefer. I wouldn't say we are in a PMO space ourselves.

Interviewer: Thank you for clarifying that. How often do you receive data? Do you ever receive live data or is it more stage processes? What is your experience there?

Participant: At the moment it is very much stage processes. We run a weekly process, personally I would like to go more real time, I love the idea of real time reporting, but we are still at a stage where from a behavioural perspcetive, we are used to weekly reporting and fortnight reporting and we have not moved to a real time space yet. That is a bit of a frustration. It is a big organisation and we have been around for a little while and to shift the overall mentality on reporting is a big job. But yea a number of my peers would share the opinion that the sooner we can go to live reporting the better. You can do decsions based on real time infomraiton opposed to something that is a week or two weeks out of date. The world moves very quickly these days.

Interviewer: How many PMs do you get data from?

Participant: A very good question. At any time we problably have between 800 – 900 projects running. That is not necessarily one to one relationship, so many 400 – 500 PMs.

Interviewer: Is that a global number?

Participant: Yes it is. We are increadible in the retail focused in the UK but yes it would be overaching number. What we are also moving into is an agile way of PM as well. Traditionally we do a lot of waterfall but we are moving into the agile space and have been doing that for the last couple of years. We don't only got PMs but also this concept of scrums masters and such.

Interviewer: You mentioned your 6 weeks prediction models. When you move from a waterfall to an agile methodolgy does that affect your prediction models?

Participant: It's a really intereting one, part of the purpose of Agile is that you are adapting constantly, waterfall is very much, once you build this product and then keep on building it, it may take us three years. In the agile world you are contactly adapting and building MVPs and things and yes it does change our time horizon. So currently the predicitve model is very focused on waterfall porjcets we are currently working on somehting for agile projects as well becsaue of that regent of different post to an agile project and the the way they would value the predciton or not value it quite as much as other do. And the reson we chose 6 weeks is because traditionally we run fourtnightly reporting so that would be three cycles of fourthnight. So it is not just an arbitury number we have taken it so we can predict through reporting periods. We did test going further put the accuracy drops over time and it seems like 6 weeks is optimal where we are at the moment. We would like to extend if we could and we probably will do. We ourselves are quite agile.

Interviewer: To ask about the variety of data? What challenges do you have in this area?

Participant: All of our data is fairly numeric, we don't take any pictures or things like that. So yes fairly simple to analyse because we are very lucky that one of our data anlytics are an expert in

text analytics so therefore progress reporting and free format texts and descriptions. It was initally somehting we avoided, they were much trickier to use in models. I think viariety of data, we do have variety because of the systems we use in terms of types of data but it is fairly structured beside the freeformat texts.

Interviewer: Is it correct to assume that the type of data does not matter if the data types are structured in a certain way?

Participant: Yes exactly. And through all our systems we have a key alignment so we know what project the data belongs to. That again, in the early days, I mean last year, when we started out there was a challenge because there was not nessesarily a consistent key across all systems but hat has been enforced now and it makes our lifes much easier. This data set is related to this project.

Interviewer: Do you measure the accuracy of data in any way?

Participant: We do have separate teams that do look at the quality of data. A really good example is risk initiation management, where we ask PM to review them ona regualr basiss and you know addressa ny impact conveys. What we sort of found from the data we have access to anf the modeling we have done is that there are a number of projects that will just almost “kick the can down the road”, they have a risk and they will review it and update it and change the review date and chage the impact every month and just move everyhting forward which isnt really good management of risk information. They are not actively doing anything except than changing the date so we see that like almost an accident. Which we reply back into our team which do look into data quality. Traditionally, the data quality matrix the guys use are very binary, have you got a date yes/no, not necessarily looking at how that data is managed, what we continously reiterate among our stakeholders is the accuracy of the model is founded on the data that goes into it. One thing we are working on at the moent is almost like a quality indicator to each project which will provide the user with a view of how trustworthy the score we are providing it is. I suppose to bting that to life, if you have a very low data quality rating, then I would expect the accuracy of our model to be fairly low beceuase we are basing it on data which is not that good. So therefore the trustworthyness of the informaiton in the score would be less trustworthy than a project that has a high interprtey of data quality and thereofre we determine the score for that project would be a lot more accuract and reliable for the project team themselves.

Interviewer: How about the time you use the prediction model? Can it be use at anytime of the proejct, such as the control of projects

Participant: Yes I would say so, I mean it can take some time to set up the data and the model correctly. But anytime reallt works. You mentioned control and this is a clear use area where we use our RAG model and control the tasks and projects through this model.

Interviewer: When something goes wrong I refer to project escalation, you mentioend it before that there can be some resistance to understand why the model is indicating a certain thing when the PM does not agree. What is the process then, who get's the last say?

Participant: Well both are considered but they can have different views on the samne problem. Maybe have different view of severity of the problem. We analyse the data and model's output with the PMs. Hear their view as well is important othervise we would never be listened to.

Interviewer: Do you see some repeated beahviour with escalation?

Participant: Sunk cost is a classic thing I often see. But I can't really say I see other patterns. We want to have a healthy relationship and culture to act when things go wrong. Some projects keep running while they are clearly not doing well. This is what we want to avoid and to bring things to attention before it is too late.

Interviewer: Is there a way for your models to determine the quality of the data? Do you understand my question?

Participant: Through the work we do as a team we try to be as transparent as possible and use humans as much as we can because in the end of the day we are almost using the wisdom of the crowd and we know that on average projects will rate themselves red correctly, green correctly and amber correctly, so we use the wisdom of the crowd for the accuracy of our model to begin with. What we then do, we are quite fortunate to have the delivery assurance team I talked about in the beginning, those people within that team are sort of very experienced project and programmes managers so their nature oft ehir role is that they need to be very experienced because they are the ones that go out to the very big investment projects to do an assurance review manually so we very much use their knoweldge and experience to validate the model we have. So we have gone through various iterations of the model. What we do each time as part of our build and our test is not only to test it against previous iterations we have done but also get the guys to validate it as alsmost as a desk based experiece so they will pick 30 or 40 parents(?) at random and they do an individual assessment on those Parents/PRNs? And comapre that to what the model is showing us and if we need to to ajustments we can do, that is really good, I suppose us to validate our own modelis tracking in the right direction. So yea we always use humans.

The other question I think you asked was around was if we prioritise certain bits of data. We do maybe not the same reason for why you are asking, but we do weight data varieties differently. Our model looks at risks issues, change requests, milestones, penalties, progress reports etc it does prioritse risks and issues and milestones so thse are the key item we really look for in the model and we would weigth more highly than maybe financial data which we know historcally can have some kind of time lag before it is updated n the core systems. So we do it in a slightly different reason for what you are asking.

Interviewer: We have passed the original time we set, but I would like to ask a few more questions if that is okay?

Participant: Yes that is okay.

Interviewer: Natrually projects deal with internal data within the project. Do you utilise and collect data from an external enironment?

Participant: We are as part of the team, but not really for projects themselves. Primiarily we are analytics but be are asked to do as well, but yea not really related to projets. The only exception is problably what we call group wide or bank wide risk information. We look at some operational risk and potentially the impact that projects can have on things like opreartioan lrisks So we do look at risk data sources as well, that do sit outside I suppose the “normal project” data sources.

Interviewer: Organisations in the finacial industry must have a large department looking for global trends and risks data which is distributed throughout if needed?

Participant: Yes, and like I said primarily we look at delivery data and a bit of risk data as well.

Interviewer: To ask a straight question, which may not be simple to answer. Do you believe you are using big data to deliver projects?

Participant: That is not a simple question to answer, it all depends on the definition of big data. We all like to think we use big data but when I look at how much information we use, which is significant but then we I look at the data the organisation has across I suppose like the cutomer base for example we are using a fraction of data in terms of size that they would use. I do find it quite a hard question to answer, I apologise for the ambigious answer, I would probably say no, we don’t use big data in that sense. We have a defined set of attributes we are pretty lookinf at 21 million bits of infoermation on a weekly information, but you know there are billion of bits the company has in total. So it seem s as a big number, but is probably not.

Interviewer: I don't want to control you answer, but would you say the compnay the organisation uses big data?

Participant: Yes, absolutley, the organisation itself uses it. In my team we probably like to think we use big data but realisticly we don't.

Interviewer: I suppose it may be a question of reference point? You have lots of data to begin with, but hen compare to another industry where they need to take initiative to collect the data they might think different. You are able to see the availble data in the organisation you don't have access to.

Participant: Exactly and that is due to vast amount of data the organisation has. Yes to the organisation.

Interviewer: If I may ask I question regarding predicitve analytics. What is the different bettwen predicitve and prescriptive analytics? And do you use those terminologies?

Participant: No, sorry we don't use those terminologies. One of my data scientist would probably easy be able to answer that question.

Interviewer: Maybe it is only used in academic journals and not in industry itself?

I have heard of prescriptive anaytics as well. Data analytics is sort of a hierarchial triangle. Where you have really simple analytics at the bottom, then you have trend analysis and historical, and then you get near the top have predicitve and prescriptive, but yea I can't articulate what prescriptive is.

Interviewer: I have one last question. I have come across an organisation which uses a chat bot as their line manager. Would you be able to use this in your organisation? Or is your communication with the PMs more complex and you don't think it would be possible?

Participant: I think it is quite interesting when you apply it to project management. Chat bots to me are very good when you have very clearly defined process and things a farily stable. Whereas in project management a lot of is founded on communication and you got things like dependency management and commnunication between PMs, you got riskt mitigation and mitigation team with suppliers and all of that good stuff. So no it's not something… I think there are certain things you can do to automate, you can potentially use a chat bot for that. But I don't think the overaching, almost like the role of PMs is something you can use chat bot.

In other areas in the organisation we do come across chat bots, in out IT ordering department where requeststst get taken by a chat bot. And then it is a seamless hand of a human if the chat bot cant ansewer the question. So yes through out the group we use chat bots, HR department

as well, if the chat bot can't answer the question it will hand of the question to a human. But yea specifically for PM it is a bit different. I think you can a chat bot questions, I don't think you can get a chat bot to actually manage the process.

Session 2 March 2021

Discussion over phone validating the causal loop diagram (not recorded)/

P10 – March 2020

Interviewer: What is your perspective of AI in PM?

Participant: We find ourselves in a very big paradigm change. We also find ourselves in an industry which has often been referred to by others who refer to the project industry as a technology wasteland, so it's in for a chock. And all professional services for that matter.

Interviewer: Can you explain your background?

Participant: I'm in XX country and we have been working in construction projects to develop a machine learning model to improve the waste of tax payers money.

Interviewer: Can you tell me about how you came to where you are today and why the profession needs the product your company deliver?

Participant: Once again, accidentally, maybe luck or whatever we want to call it. I have spent my career in project management, I've started managing road contracts in the middle of nowhere. And then later on I found a project management firm, which was relatively good, having 80 or so staff and doing a lot of large government projects and so forth, which was fun. And I sold out of that in 2015, and went back to university because I could.

….[anonymised interview data]…

But what we have found remarkably, this approach which is essentially a leveraging of referencing and forecasting approach, which you'll find XX has done a lot of work on and he's done that from Daniel Kahnemans's work in the first instance, Ben is part of the company now essentially all what we've done is taking a bunch of academics theories of which that is one and turned them into a thing that works which is AI. People who developed those theories feel excited and initiated by a threat process because we have been able to prove that it actually works, really works and has some nuts and bolts. And the results have been just remarkable, I can't believe how good they are, but that is probably because of how bad the ususal performance is. If you look at project management in general right, we really got three things that we are interested in doing, you meant to have some benefits, within a certain cost for a certain time right? And in my mind I kind of picture the world quite simple I think you actually only have three variables, you can mock around with the scope which will change the benefits. If you build half of a bridge you won't have the same benefits as if you'd have a whole bridge. Quality is a lot of rubbish that is just a piece of scope, you can mock around with the resources that you apply, because money actually doesn't do anything all money does is to buy resources,

it buys us, people, concrete or whatever. Or you can mock around with the duration that you take, these are the variable right? In the end we try to develop benefits in a certain time for a certain cost. And as it turns out we generally don't, we in our company try to stay away form benefits, beceause that is a very political area, it is hard to measure, you know. I recon if you looked at the pyramid of a business case you wouldn't find tourism there, yet it is a very big benefit. So trying not to do that, we try to stick to simple things as time and cost. And fortunately for us, the currently performance is very poor and that means that the AI doesn't have to be very good to be a lot better that the current performance. But the real issue is, and I think this is where people like yourself come in, the real issue that what I've discovered, the thing that drives us is that, you know we see time and cost overrun as a more as a social evil than a commercial problem. You may or may not, well you got crossrail of course, Crossrail is not too bad. That is only £2 billion over and that is not too bad considering the take. I mean we got one down here that is 12 billion dollars and it's 4,5 billion dollars over, that is just what they have admitted to so it is probably more. So if you look at that, 4,5 billion dollars that's eight regional hospitals, maybe ten. Eight or ten hospitals that the people in new south wales don't have since they spent the extra money. So we regard that as a social problem and people should do something about that, you know.

Interviewer: You mentioned the construction industry, is this the only industry you operate in?

Participant: It is the industry we have started in because it is where the low hanging fruit is, plus it is where largely our team has come from you know. When you try to make a new enterprise approach, and you try to change a paradigm of thinking, which we are trying to do, because the use of AI in projects is a huge paradigm change in the thinking of project management in general. So I will just talk about philosophy for a second, if you look at PM as an entire industry, it is a foundationless philosophy. You know, a "manual camp would like it" (not sure what is said here), there is no actual empirical evidence that says that it works. There is no empirical evidence saying that it works, you know I had an instruction with somebody the other day about IBM you know, and I said "well where is the evidence that IBM is actually better than anyone else at actually delivering any outcomes then projects that don't use IBM?" Well there isn't any, nor has there been a study, we have different source of methodoologies, we have lean, Prince2, PMBOK, Wtaerfall what ever right, I dare you, I double dare you to find an emprical study that shows that lean actually produces any better results than Prince2 or PMBOK or any other. If such a study existed, the people from lean or what ever would do somehting about it, [as an example] all I am saying is that we just don't know. So we believe that it works, and we even have a book called "the Book of Knowledge" right, and we actually believe that this knowledge is saturated. How did we come up with this knowledge? We didn't measure anyhting, all we did

was, you know I grew up with PMBOK when it only had a few chapters, and I believe it is great and marvelous thing. But if you look at project management, its functions it under rates basic method of thinking, which is this: things that happen on a hap hazzard basis, that are disorganised usually stuff up, therefore you organisae them and they'll stuff up less, therefore if you keep organising them in more detail it will stuff up less and less, right. That is a belief it does not have any actual eveidence for that. That is a big philosophical difference from you know David Hume who said "well we can't even rely on the sun to rise the next day just because it has risen everyday so far". Very interesting theory, although I do like David Humne. In terms of empirical and the difference with AI or at least our form of AI, is that it is entirely empirical. That is a really hard transition for a profession that is based on fundamental truth of organisations which is not very suprising which it was built by engineers, I am an engineer so I can criticise them. And engineers as a profession we are very cause and effect based, which is a good thing, because if we wouldn't buildings would fall down. But you know, classical physicists, you can't get to quantum physics by thinking as classical physiscs, you can't do the transition, because it just doesn't work that way, so I say you can't really get to use AI technology that is based on big data by continuing the thinking in the way that we believe is the right way to do stuff, despite the fact we don't have a lot of evidence [to think like that] for it. You know the airline industry had the same track record of smooth or rough flights of failure as the project industry, there would be no more airline industry.

Interviewer: Thank you for explaining your thoughts on that. You seem to have three different solutions for companies; startup, business and enterprise?

Participant: Yes, well actually we ditched the start up, we only did that two days ago. Because we found some remarcable stuff that we didin't expect to find, and we were looking for, you know the product fundamentally started from an enterprise solution, because we need a lot of data. And if you look at the product/project industry because everyone knows, construction projects is so, really in all projects is the surname, but particularly when you have different stakeholders and conflicting parties, so if you look at project work generally in the world, you will find that in the OECD about one third of all the work hours worked in a project environment and that the most project intensive industry is construction where 80-85% is in project environment. The second most industry is professional services, it is interesting that those two industries stand out as the ones who have not increased their productivity at all since 1995. Which is pretty depressing since you find e.g. agriculture has gone up with about 45% since 1995, like medicine and IT keeps going up. But professional services and contruction is not increasing their priductivity which is a sad enditement. Nobody is very surprised of this and in those industries, except for professional services, but professional services have an agency problem that it is in their interest to be unproductive. Because then you can charge more hours.

Interviewer: Is that based on that these industries, as you mentioned before, are thinking in a more strucutre and traditional way?

Participant: I think we that there are reasons why those industries have not improved their productivity, and there are different reasons, in those industies. One of them is a straight agency problem that we invent the wheel every single time. If you look at lawers and you can read some of the work by the Susskinds boys, Daniel and Richard, who have a pretty dim view of the future, I don't necessarily think they're right, but some of what they say is down to occur. But if you look at those guys and you look at professions generally, and I wouldn't call project management a neo-profession, probably it is the most successful of the neo-profession, because of you look at project management, it has managed to globalised its mantra, right, more even than law you now, and it managed to do all this in a very short time, you know. It's amazing, it has managed to take over a third of the economic activity of the world, and that is pretty good. So I think there are different reasons, construction productivity, well there is one area of constuction where there has been massive imporvements and draw the own conclusino as to why this is, but safety has been a massive imporvements. My view of that is that safety has been the one area where people has not tried to complete with each other but generally tied to collaborate, because nobody loses. The poelpe of one company don't feel any better if there is a fatal accident on another site, so there is a deep collaboration around safety and the other thing is that legislators have made leaders [managers] personally responsible. If a project run a billion dollars who is personally repsonsible for that? I don't know what the solution is for that but...

Interviewer: That is very interesteing point, thank you. Can you explain the difference between a startup and an enterprise and the micro data versus big data?

Participant: Okay so, we started from the enterprise level solution and the enterprise level soilution really meerged from the fact that there are two attricutes of projects that restrict of what you can do in terms of AI and that is because it is such an industry of such conflict not only in construction, the IT industry is the same, maybe change projects are not as bad, but whenever there is a contract between party A and party B and there is a transfer of risks and when there is numbers involved, big dollars involved, there is likely to be some sort of friction and what you find is that the parties, everyone in construction knows this, ande veryone in projects knows this, the party basically use their own data and data is the fuel that you need as weapons. The result of that is data tends to be hoarded and there is a fear of data. You got "data fear" and "data hoarding" right, so when you try and build a solution or anyone the most obvious to build on enterprise level is a solution that is organisation specific, because then you don't have to get anyone to share their data right. Eventually, we hope, and in fact we have a social purpose to our company, and this is is, but eventually we hope that people will realise that there

is nothing to lose from anonymising and sharing the data, and everybody wins. Less friction between expectation and outcome. So that is what drove us down the path of enterprise, then we tried to say "only the really big organisations can not only the contractors but the big clients organisations and consultancies, and the big organsiations have a lot of data so you have a risk of creating a social problem, when you provide an advantage to giant organisations to a disadvantage to smaller organisations. The advantage to smaller organisations is that they are smaller, they can make faster decisions and they are more flexible etc. But if you create an environment where big organisations are able to do that more effectivley then small organisations, because they have more intelligence, then you are forcing the smaller companies out of the business. We don't need more of that, then we started thinking about how can we do a cut down version of this, how can we look at what we learned and reduce the number of variables and the complexity of the solution so that it can be applicable to smaller organisations, so that probe is to the business level. And then we thought well how do hook organisations in, and we had this idea, and you these are the ideas that "you try the ideas, sometimes they work and sometimes they don't. So we said let's try the startup thing, let's see if we can create such a simple thing, on such a simple level that you know you put in one line [of codes] and you can get some sort of outcome, we recently discovered, that with very few lines [of codes] we can get a really good outcome. Which is counter intutive, that you know, like less detail is resulting in better prediction, which is totally counterintutive. Some might say the ML guys have, I said can you explain this? No not really yet haha [laughing]. "I said you have to work harder fellas" haha. People are going to say "how can this be?" and I will go "well I don't know". The results of that have been that we think we are emerging into this area where the startup level and this business level is emerged together. And there is really not any difference between the two, but you the guys are still working on that and we are still finding stuff, some really remarcable stuff.

Interviewer: Thank you clarifying that. Can you explain again more slowly what you product does? What is it the AI calculates?

Participant: Yes sure, I don't realise talk too fast and you may not have the full context. So I am going on rants and then you have to stop me. The AI looks at the risks and tells us if anything is going to happen really. It makes forecasts and works as a warning system to discover things that we otherwise would be blinded to see. Do you understand what I mean?

Interviewer: Very interesting thank you. I would like to ask about your social purpose, is any organisation able to join this? Or is there certain criteria for organisations to fulfill in terms of data?

Participant: Let me answer that question in another way, in the first instance we had 2024 under our schedule, it is not an easy thing to do, because there are all kinds of issues of data ownership, governments, and private organisations, such as land lease, who think their data is the best data. The engineering firms are the worst. Even though most of their data is crap, neverthless they think that data isn't, and they certainly tell their clients it isn't. So but we look at in terms of this, "what is the problem? Why is it even a problem that things should cost more or take longer then you predicted they would? Why is that even a problem?" and the answer you come up with is that there is a lot of stakeholders in projects of all sizes. And those stakeholders have expectations right, the customer expects, or the owner expects that it is going to cost 100 million dollars. The contractor expect that he is going to get 120 million dollars, if the contractor expects 120 million dollars and it costs him 140 million dollars, then he has an expectation gap. The problem is the expectation gap, the gap betwwen what people think is going to happen and what that actually happens. And what you have seen you know, people say that projects are getting bigger and that is rubbish. Because if you look at the exudates of Rome and others, you find that one of the equident in today's money value they were worth 28 – 30 billion dollars, so that is a big project. What is happening is that it is getting more and bigger projects, more of them, you don't have many pyramids of giza and the numbers of stakeholders and regulations and the like surrounds projects is increasing in exponential rates which makes them more complex. Once again you know, if you look at the stakeholders at the pyramids of giza it was the pharao, no one really counted [mattered]. Nobody had any views on that project haha [laughing]. So, to me, that means that the complexity of projects is increasing so, complexity is increasing, more humans are involved, more stakeholders involved, and so forth, which generally just draws everything into a far more difficult way of dealing with it. So what we've done is that we've created a more complex environment for ourselves and we can't uncreate that that is just the way the world is. In the same time we have you know massive data we have to manage and so forth, it is just too big for humans to do. So, at the moment when that data is created, all that data is valuable stuff that can be used by AI machines, and that data, though, sits in different parties that love to disagree with each other that think they are special, and use it to have commercial disputes with and you can't stop that. But I look at like this, "who's data is it?" If I hire you to build me something at my house, when you do that and you put the timber up which I have paid for the timber is mine. So at the moment what we found we are creating data which I pay you to create and if its my data why does it have to be specifically my data? When we look at other industries, particularly medicine, medicine has a couple of things our industry don't have, first of all it is data is really well collected and regulated and the reasons for that is that if a doctor does an activity and doesn't record it properly he doesn't get paid by the NHS or other health providers. So there is a commerce to adicatley record what they do, secondly there is an issue in privacy and security of data have been dealt with during decades and we have

dealt that in the project industry by not sharing it with each other, sometimes we don't even share it with ourselves. You can't get one part of the lease to tell the other part what to do you know. Or one part of goverenment and another part of the goverenment. And thirdly, so the security and privacy ideas are dealt with the issue of effective common reporting of data has been dealt with and thirdly the industry of medicine or education they have a tradition of sharing the knowledge for the common good. And we just don't do that in projects, we have a tradition for fighting each other for our personal good, it is long standing tradition and rigid atmosphere. And when I add my project management consultancy we made a lot of money on having these fight for one party over another party. So I think if we look at the data trust we need a visage and not for profit thing, a bit like the red cross like, so it has to be located in geographies around the world and it had to be global. Because let's say you in the UK decided to build a new big dam right. Well there is no use if you get all your own UK data because you haven't built anything for ages all the data about big damn is in the third world and in the US, we haven't built many in X country, so the data that informs your AI machines or techonoogy use of data that data is not country specific so it has to be global. With all major projects, it has to be global data, and really, you think about it, if we have the data in X country and we provide it to some centralised point and somebody in the UK uses it, what difference would it make to us? There is no downside for us, the world is more productive and that would be a good thing. But that is a big paradigm to overcome.

Interviewer: Based on Big Data. Would you say you have been exposed to big data volume? What are your thoughts and experience in this area?

Participant: So our current best performing AI machine works on around 200 million data points. That comes out of around about 600 different projects, that is a big data set, to get 600 projects that you can clean the data and get it to make sense, that is a big data set, what we have found though is that you really need to get a really good outcome based on project cost metrics and to do time is harder to do than cost, and there is culture reasons for why that is the case, Oracle knows what they are because I talked to them last week. So to do time is harder to do than cost, cost is easier so we focus on that if we don't have nothing else to focus on, but we can do time as well. We really need about, if you got good data, to get a decent performance you need about 120 projects. Somewhere in betwwe 100 and 150, if you can get 500 or 600 its fantastic, but not all of that data comes from, is what you would define or what people generally would define as project data. So some of that is public data, for example we can drag weahter report into it, postcodes, labour intensity, you can bring in a lot of public data into the machine to see whether or not it can better its performance. The way the machine then does that right is that it drags all the data in and then it continuously runs itself to try and find those items that affect the outcome the most, so as it continuously runs, it finds insight from bits of data that

become marginal so it can drop that data off . So we start with rougly a 100 variables and we can probably get that down to 100. So 200 million of big data set.

Interviewer: Thank you for sharing that. You mentioned variety of data, have you been exposed to a wide variety of data and what is you experience of this?

Participant: What we have found, and we are still discovering this, we still discover stuff as we go along, because there is no one else to ask, no one is as far in comparison. “Plur”, “Fleur”, you should talk to Plur if you can, when they where developing their AI machine with IBM Watson and I think they are probable the best comapritive to what we can do. I think you know in terms of variety of data what we generally have found is that with any machines like with any human being you have to start teaching them with pretty structure stuff. So you know if you want to create a match person, you have to begin with 2 + 2 = 4. But there comes a point when you can just put them in the library and they teach themselves. And sometimes we have found there is not enough for the machine, there might be a lot of data but the data does not got the structure that enable us to teach the machine anything. We have packages of terrabytes of data but we can’t do anything with that. So that is important, but then after a while you can just chuck stuff in to see if it makes a difference. We dicsovered that one of the main influences or proedictors whether a project for a particualr client was going to make money or was what post-code it was in. And the customer then said “well what is it about the post code?” “Well we don’t know, we just tell you that is the outcome.” hehe [laughing]. So variety and the next thing after that is, we just started this for the world bank, the next question is if you implemtn a NLP into your AI machine then you can start doing all sorts of things. And actually find out if the risk analysis works in the end, or any good or not, you know. You can’t do that yet though, so that is the variety.

Interviewer: So what happens when a risk is identified? What is the decision process then?

Participant: You look at where the problem sits, and you act on it. There may be some trust issues if the organisation is not used to the tool but the issues goes to the decision-maker and the issue is reported. We usually don’t have much issues of interpretabilty because we work people who are used to these models but it is a fundamental challenge to act on a risk but not having the explanations for why something is happening.

Interviewer: This is somehting I refer to as escalation, project escalation. Thank you for that, you mentioned you found a correlation in the post code for some projects. Can the computer find the reason for this correlation and causal effect or do you as a human have to do that?

Participant: So that is a really important point in projects but also in medicine, but not really important in self-driving cars, that is interpretability. Interpretability in some instances is critical, so what I mean to say is, a self-driving car when there is close to an accident you want the car to apply the breaks. And you need to rely on that. You don't really care why it decides to pull the breaks, but you need to rely on it. In medicine or in a project if you come up with an answer "well you should do this" and somebody says "we should take these double quantity of chimotherapy", the patient says "why should I do that?" the doctor says "well I don't know it says so." [It doesn't provide the trust for the patient] Similary for a project environment where we are cynical about what machines can do and we are welded to a previous, resisting paradigm of cause and effect, to say to people you need to increase the staffing for this project by 20%, and then the executive manager says "why do we do that?" and you say "well I don't know..". That doesn't really work, so this comes down to what sort of AI, what type of AI or branch of ML you are using to provide you with the insights. So like our brand of ML or a component of it, is a knowledge tree model, so within model tree knowledge you can backtrack and see how the machine made decision. But I know others who use a deep learning model, and a deep learning model and the DL model which is a method which is milar to google go chess machine. When it played its move on there, they thought it was something wrong with the machine and yet it won, but no one could work out why, so that is really important point.

Interviewer: Very intresting and facinating topic about interpretatabilitu. Have you experienced a live stream of data? And what is your ambition?

Participant: So to answer this question is the same question as to why AI is any better than humans, or is part of the answer right? So look at what happens now, lets look at, so I am just focusing on time and cost right. What happens right now is that we, the builder EVM model which cost a huge number of people or we do it in a normal sort of fashion where we got a schedule and a cost plan and people And what happens every month, it is not even an argument about this, everyone agrees on this, that every month the cost plan or the schedule goes around and everyone says "how far are you" and the answers to that is they get out are full of bias. They are full of ignorance beceuse sometimes peopole don't know so they take it up, with the best of intentions and then that information is then interpreted by a human which is the cost or schedule owner, and then this person writes a report. And he gives that report to the site manager alright, the site manager looks at it and says "oh shit this isn't going very well, I better fix it". So then he writes a report right, and the report that he writes which goes to the PM or construction manager depends on the job, that report probably down play the difficulties and negatives things that is happening and that is a natural thing, because you know I paid the site manager to sort out problems, I don't pay him to bring me every problem I expect him to do something, so you know if the problem is fixed and I don't hear about it again you know

everybody is happy, but if the problem is not fixed, the next month it is bigger problem than what it originally was and now it gets reported to the PM and the PM goes “well I need to fix that, I am not going to tell the construction manager”. So by the time it reaches any senior or executive, by the time that it gets to somebody who really needs to make some decision, it is at least 3 months old and probably really clogged up, and your ability to fix it is gone or limited right. And in fact when I was talking to one of guys of XX company, he said to me “What 3 months? Bullshit, sometimes it is a year before I find out.” So that is the normal thing right, the question is how do we increase the velocity, and the answer is that it will inevitably happen and that is beceasu over the last 3 or 4 years most organisations have started to digitilise. So we have digital information being produces, it won’t take people long to work out, I’ll take a stright example when I spoke to a design director of an airport, working around 50 million pounds, he got an army of engineers outside his office. He said to me “well I still need to get a monthly report” I said “no you don’t”. Every time wokers and engineers are working on XXX and every time they do somehting they are rivering (changing) the drawing. Everytime they are rivereing the drawring is a progress. What you are going to do is to interpret what that rivereing means and you got data straight. The guys who are working don’t even know they are proving that data. But you need to have a machine to interpret that. So I think that will happen inevitably.

Interviewer: Where in the project lifecycle do you experience projects create most data?

Participant: That’s a difficult questions. Beceause even though for example a huge amount of data is created… I think the question isn’t, the issue isn’t when is most data created, it is when is most data created compared to the time that you have to interpret and act on that data. So in pre-business case, take the normal 500 million dollar job right, pre-business case a lot of data is created, a lot planning data is created, a lot of design data is created, a lot of estimate data is created, but pre-business case for a 500 million dollar job might take three years right, so if you get the estimate wrong you got plenty of time to mock around with it right. Many times, the data is project-specific, but it can still be used for training; some professionals have issues with this. But then when contstruction starts the dream time is over, and once construction starts a lot data is created, that data is less accessible than the data created pre-business case because people are sharing the data before, and secondly when the data is created your ability to act on that insights to interpret that data or act on the insights is a lot shorter because things keep changing. So I think it is more a matter of, the amount of data that is created compared to the time that is available to interpret it and act on it.

Interviewer: So when would say that would be?

Participant: Sorry what do you mean?

Interviewer: Sorry, then would you say is the shortest time is to interpret the data? During control and implementation?

Participant: Yes probably during the last two thirds of the implementation. You can control any part where there are risks. So you know in our data analysis we discovered for example that we did the mean, we did an analysis of mean, human prediction time, compared to project outcome and we split that prediction between proejcts that were coming under and over budget. That was about 100 million data points, and we found that bare in mind that when human make predictions during projects, they don't know whether it is coming in over or under budget so we were bound to think it is. So we were looking backwards on this data, and we found that if somehting where coming under budget that your team would team would accurately predict that by about a third into the project. But if it was going over the budget they wouldn't get to that accuracy until two thirds into the project right. So I would say it is the last two third of any project, there are all different projects, but I would say the first third is okay, but it is like studying to an exam or do a PhD, you got three years of doing a PhD and the firs year is easy and the last year you think "wholy shit now I am going write this bloddy thing" haha [laughing].

Interviewer: Do you operate in your region or internatonally?

Participant: We operate internationally. We have some alliances..... (more unrelated in the original audio file). And we also have a relationship with different academics. But it also has an advantage in enabling us to access high-end clients, if you like, which we wouldn't have access to otherwise. And showcase our stuff to Heathrow Airport. I have a view that a way to be both commercially and technologically successful is to spread fast, and the best way to do that is to form partnerships and to spread love rather than hold on to it. It is better to have a piece of something large than to have all of something small.

Interviewer: What are the possibilities for a phd student to collaborate with you on data repositories or data trusts?

Participant: The problem with data trusts is that there are not many of them. You can look into the open data on the internet, my problem with the british one is that it is build on national data.

Interviewer: So we are running out of time, is there anyhting you would like to discuss or add?

Participant: Oh already? Lots of things but I don't have to go on another rant haha [laughing].

P11 March 2020

Interviewer: Can you tell me about your background?

Participant: I have been involved in implementing, and buying these software tools for many years, and the problem has always been on how they've been integrated or not integrated with how organisations function, and it is kind of prompt to me to write, not calling it a paper, more a glorified blog. Saying this is how I think AI is not working. As a practitioner the number of times I have gone into organisations and even people who are quite experienced project managers, they say "oh you are trying to make us following best practice, that's is all very well in theory. I say no it is all very well in practice, that is why it is called best practice" hehe [laughing].

Interviewer: To give you some background of me, I come from an academic background as a social scientist of project management. What is your thoughts on project mangaement practice and theory?

Participant: What that enables you to do is that you can be scientific aspect about it and you can look at it from an evidencial view about it. Even though the interview is additional evidence, you are taking in views from multiple practitioners and other people so that you can then weigh those and assess those, not coming from any particular viewpoint or agenda. That is really useful.

Interviewer: I understand, I try to stay unbias regardless everyone's own agenda. This topic is not mature enough that makes me able to talk to anyone, so there is a selfselection process.

Participant: Yes that is true, you will get some people like me hehe [lauhging jokinly].

Interviewer: If we start from the beginning, can you talk about your experience?

Participant: Okay, so who am I am a semi-retired project management professional, that is how I describe myself and I started out in IT 35 years ago. Within 5 years I was running software development projects in a telecommunication company, that made me move into internal traning and consultancy. I was teaching people in software design which led me into learning about how to run small projects, and I learned about project management and started to teach that and business analytics and early AI. I then moved into the engineering division where I was running big engineering project and programmes for a bout three years and then I helped build what we today call an etnerprise project office and management about 2 billion pounds a year of engineering investments which was entirely projecitsed, even if it was business as usual

sending out people reparing stuff, the budget of 2 billion pounds a year was completely projectified. Some of it was the very early stages of broad band, very early stages of rolling out fibre optic cables, all that was projected. Usually around regional, what each reginal in the conutry did was given a budget this is how much cable you will put into the ground this how much money you can use to do it and to measure against that. So that was moving from project management to the very early parts of analytics, we were one the organisations that was starting to evole programme management because project management was not longer fit for purpose for the increaing side of complexity of the things we wanted to manage. And then we wanted to manage hundreds of projects, douzens of programmes and that was when we took some lessons for the US and started to do portfolio management and some anlytics, not machine learning yet though, this is this early arounf the 90's. That was the point I joined the profession as a professional bode APM, and they had a programme management group which was again starting to evolve from best practice in parallel with UK gorvernent's best practice, and as a group within APM we went on over the next 10 years to start the ball rolling on developing best practice for portoflio management and then defining best practice for the design and build and upgrade of project and programme offices up to enterprise level and the other gorups came along and they took that expanded it greatly so we started the ball rolling.

Alightly going on a tandrum with the professional side of things but essentiall I left the telecom company at the end of 1995 and then from that period on until now I have been an independent professional the first 15 years I spent on large tranformation programmes or rescuing them an dimplementing analytics when ever I could. I have experience a lot of different industries, I've done telecommunication, aviation, central and local government, and worked internationally in three different areas of finance in mining, oil, globally as well as coffee hehe, which was good fun. Worked with the people who supply the machines to the coffee shops and they were havning problems from groing very quickly, spent part time year and a half to helpeing them to kind of raching their business models.

Interviewer: What industry would you say you have been most within?

Participant: Software has been a commonality but in different contexts. You can say software really, doesn't matter for me but for the sake of simplifying you can say that.

Interviewer: You mentioned tranformational? Can you expand on this?

Participant: It was more operations, as they were growing so quickly, that all that the various bits, the sales silos worked well , the supply silo worked well, the maintenance operations worked well, what didn't do well was the linkages so the work flow across the business, they were terrible. It was my piece of analysis where they understood that it was the workflow that

was the problem. And I looked into one or two other areas like their lack of efficenty of their housing and stuff like that but was faily small bit.Okay so I suggest you doing this to fix your work flow to pay more attention to them and be less silo which meant that each silo had to talk to each other more you know [joikingly laughing].

And that was fun, it was owned by an italian guy who was passioanted about coffee, and every time I went there, he persoanlly would make me coffee which was great hehe. So that is about it.

Back to the professional side of it, back 10 years ago I kind of went from running and delivering projects to as a more pure consultant I also got more and more interested in agile and realised I've been doing it for years without knowing it and realising that actually really good project maagement professional are agile naturally. Because they don't do more than they need to do, it is as simple as that so the really good project managers are natrually agile. I have always been interested in developing professionally and software systems and what does that actually mean, most of my work has been pure consultancy working in organisations. Spent 9 months at an airport, they had a fantastic culture, they didn't call it Agile but we put in an Agile project management approach there. Very lean, very collaborative, very "can do", with some fantastic people, and I thorughouly enjoying these things and finding where it it possible to add analytics and angles of AI the last 8-9 years. That is basically me. Within the profession I am a bit of an anarchist because I have been one of the poelpe who been pushing the limits and saying where do we nee to take best practice, it is not working a well as it could, where do need to take it and how can we adapt it. This is great piece of research but they are terribly conservative, and they don't like being pushed. I am one of the people who pushes them and they don't like that very much.

Interviewer: Can you give an example of how they don't like to be "pushed"?

Participant: Well agile, I am co-author of two of the main guides they produced and they really did not want to produce them. Because they have these SIG, risks, government, assurance etc. And I said we need an agile SIG but it wouldn't be like the others like they sit in silo, not entierly silo, they to talk to each other but the agile one would specifically be one that looked to collaborate across all of the SIGs and headquarters aroud what does the APM think agile looks like. They wouldn't do it, they said we will do some Agile but it sits within governance and assurance. So reluctantly I got invovled in that and we produced an goverenance guide and assurance guide. They have since produced other guides which are about Agile but they are not anything to do with project mangement. The biggest mistake people make is that Agile project management is not the same as agile development. Scrum, is not a PM method, it's a devlopment method. There is obviously a relationship, it is like oragnges and bananas which you would never mistake them form each other. Agile PM and agile devlopment both use agile

principles, but they are quite different, because they are meant for different purposes and most of the best practice written on agile PM, so governance best practice, Prince2, Agile Prince 2, Agile PMI from the states is almost entirely about using things like scrum and safe. And then putting some kind of PM background arround them they are not actually about agile PM and there is vast amount they teach out as a result. There is only one of the main BP that I think they are getting right. Have you come acros the agile business “consortium”?

Interviewer: I don’t think so.

Participant: Thay are UK based and they got several years ago that agile had PM could move beyond the confined of IT development and so that is where they started developing best practice, so I think that is the best books on agile projectt, programme and portfolio management because they look beyond scrum.

Interviewer: What were they called?

Participant: “The agile business consortium”.

Interviewer: Thak you, I will look that up.

Participant: Definately.

Interviewer: You said you have an IT, anlytics and software background, can you tell me about your expereince of AI from your perspective?

Participant: Yes, I think probably mostly from what you refer to as AI decision and expert systems. And I guess back then and until very recently these things where called expert systems. I guess the first one that every one had to work with was microsoft (MS) project as a tool to support project management. Okay there are some people that argue that MS proejct has done to hold back good PM than anything else but where I first really was using technology to support me was back in the telecom company where it started out to be an financial tool beceasue PM and programme mgt was mainly being used to manage the 2 billion budget across each region and it was only a finance system then. But then we realised we wanted to check that not only check that money was spent in the rate that money was supposed to be spent at but that the value for many was being got, ie if it was about putting 5 optic cables in the ground, if it was supposed to be 30 million spent in yorkshire in optic cables in 1992 that the amount of otpic cable that was expected was put into the ground for that 30 million, if that makes sense, so we started to look into tracking physical delivery and relating to budgets. So that meant that we were having to use microsoft project to track physical progress. And then we were having to use probably key mile stones relating to monthly budget points, so how much has been spent in the last month, how much has been put in the ground and what ever the project were, a lot of

spread sheets where coming in with things like access macros and data based for pulling togeather that was particular the case a few years later when I became head of customer projects for XXXX (specific department) and again there we were building managing probably between about 150 and 200 project per year and about a douzen programmes all customer facing and there the main thing was to track cost and key milestones. I kept the data as simple as possible for PMs and said for the point of view for managing portfolios on a whole and those key delivery/physically milestones were also related to the finacial payment point in customer contracts. So that was where we started using, then again it was kind of primitive expert systems until we actually got a degree of maturity into our way of working which where about 18 months at which point we bought primavera as an integrated tool, and that alos had a link into the main finance tool of the company so we could dynamicly link data. Also we were moing towards, away from dialups, you know this is quite back in time, 9k dialups. So we where staring to get boardband links coming in so our PMs were working at other premises or at hotels at night they could do their live updates on plans and it would go into the tool and that saved a great deal of their time and it meant my enterprise project office, well I didn't' half the numbers, I could've halfed the number of people in size, I could have halved the number of people in size. What I actually did instead I did some of the satelites for supporting the large cusomter programmes, so I could use the resources but affectively I could use the tools to make my portfolio management much much more efficient because there was a lot less human interaction and human administration of the data taking place.

Interviewer: When was this in time?

Participant: That would've been hm... About 2001 and 2002.

Interviewer: So what would you say has happened since then? That was almost 20 years ago, have you experined any improvements since then?

Participant: Yea, three things that has mainly happened, first of all the huge enabler is infrastucutre speed. Whether it is intranet speed which was pretty good anyway, dedicate intranets, but the big one is the roll out of broadband speed. So you really do have the ability for tools to become smarter to have greater functionality greater complexity, more interactions, much better user interfaces, you got far better link financial resource management with physical progress, use and value. So essentially you got the ability beceasue of the imporvements of the underlying infrastructure, the tools themselves can do far more. And that I have seen happen massively. So all analytics is not able to take anlyse more data and at faster speed.

Interviewer: You as a project manager then, how have you changed the way you work? What is your experience?

Participant: Yes, I think there is two things really. For me there is a difference, between having a tool, expert systems/AI call it what you like that has fantastic capability and the ability to organising to use it and to code as simlar to data awareness increases the ability to use it. Now as a consultant the biggest lesson that consistantly I try to get to my clients when I've been asked to select and implement technology for them, is to not do it until they are ready. And I can give an example, the worst example I think I've seen, and this was kind of different to what I was doing. I was asked to go into a big investment organisation and it just so happens that they, and I was asked to run a very big transformational programme, it was their first buisness to customer, e-commerce programme where they basically wanted to move along the processes from the company to the customer. So self-selection of items and that kind of things. So by running that programme, I was told, "we just spend half a million pound buying "Artemis"", which I still think exisits. It is a fantastic tool, but it was developed for construction, and it is a billinat tool for construction, when you do the same thing all the time. It is totally unsuitable for a dynamic environments where you do a lot of different projects. Sometime in a lot of different ways and you are having to adapt, and again you have different work flows and decision point at all sorts. The first question I sort of said was, "why the hell have bought this stupid tool?". Which didn't go down too well hehe. But I kind of backed off, and said "okay I can make use of it, I can use it", but "I kind of said, I have some predictions, you spent half a million and you will probably spend another 100k continuously reconfiguring the tools". So the first thing I say to organisations is, on a job of consusltant they have employed me to select and implement a tool. This way we can place analytics and get the data from the start. Are you familiar with levels of maturity models?

Interviewer: Yes I think I am but please expand on this.

Participant: So okay level 1 is, there is nothing. Level 2 people are using some kind of standard but it is a hit and miss, level 3 you get some consistancy and standards. Level 4 is you starting to get more innovation and adaptation and level 5 is kind of nuclear industry where you have continous learning where you have a high level of professionalism. I said unless you get to level 3 don't even bother buying and investing in sophisticated system. And I would say exactly the same for AI, because you almost always have to configure the systems. And if your project, programme and portfolio management approach is immature, that means you are still developing it. You are still developing procedures and adapting of the organisation, and adapting decision points and even templates. You have continuously having redesigning, people say that doesn't work, we don't like that report, I don't like that dashboard. So until you got to level 3 that is pretty steady there is no point in buying a tool, beceause you don't only have upfront configuration costs, you also have ongoing huge re-configuration costs. Which is what happended ot this investment company, they spent 100k in just their first year in re-configuration costs as they matured their processes. The one time it does work and I've done

this twice is for a new organisation and where you say “look best practice is built into the tool”, so why not determine how you are going to deliver project, programmes and portfolios based on the procedure and work flow and data modeling already built in the tools. That is best practice, there are still some bit you need to configure, like decsion-points, gates and stuff like like but apart from that use the tool to define the process. You can do that when you have a startup. You can’t do that, I’ve never read or never seen any organisation that has successfully massively changed their internal process, because people don’t like it.

Interviewer: Can you expand on this change process, is it possible for a single department to change in this sense intead of the whole organisation?

Participant: It is possible to do that, but if your got a lot of people who are used to work in a particular way, and you say to them “we are now going to use this thing straight out of the box”, I’ve seen this, I have been invovled on and off advising an new software company within data secturity and GDPR specture, and a lot of their client have said” because this new stuff to us to meet GDPR, we will take the out of the box capabilty”. And the director all say that, and the implementation project is done on that “ we will take it out of the box, and engineer how we work out of the box”. But then their internal audit people and their internal data secrutiy people say “no we are not going to do that, we are going to do it differently”. So the whole phase is one thing and the thing is something else. And the project suddenly becomes from “that” to “that”. And the software companies say “you are paying us for that and you now want us to do this kind of work, that is not going to happen.” Again the same thing with the suppler of the project, so that then becomes unused. You rasied a really good question, around the whole AI the use of AI and implementaiton of AI and that is people. Because at the end of the day it is people who deliver projets and you can have fantastic and amasing procedures and data models and fantastic tools. But I have gone into many organsiation where they have invested heavily in some of the big 5 consultancies, and they have fantastic way of working and fantastic tools and nobody uses them. They uses their own spread sheet, because nobody asked them about implementation of the tool, because “that is not how we do it here”.

Interviewer: Do yout help them change this behaviour or do you analyse and identify the problem?

Participant: Mostly I’ve gone in there and the conclusion has been that they have to re-configure their procedures and tools. And usually trying to simplifying as much as possible. Again, taking things out of the box, one thing is having wonderful reports and whatever is availble but sometimes there is just too much. The synic in me always says, the executive level people are very busy people. And they may say, “I want a report that says this each month” the only stuff they are going to read is the management summary, the first page. There are some

complete detail freaks who will go thorugh the wole thing. And stay up until 3 o'clock in the morning, there are some people like that. But the majority of the executive don't need that level of data nor do they want it.

To me AI systems, there are always two sides of the coin, once you get maturity, once you do get an AI system that working really well thought the organisation, what you can do is drill down because the data is all there. The notion of management by exception, I am a massive believe of mnagament bias. If the project is provenly green, not just someone says it is green but data is proving it is green that is all I need to know. Someone says I am running an portoflio, I only need to know it is on green. And the trend is green using traffic light analogy. But if its not I need the ability to quickly and ability to drill down. And it is far better if I can do that myself and get all the data quickly because I am not wasting the PMs time, I might want to call them in to tell me what they are doing about it in a more detail, but again one of the real great values in these systems is the ability to present simple information really well, with great clarity as long as the data is up to date and accurate. And that is a big IF. And then the ability to drill down, when there is a need to do so. If you haven't got the AI that can do the drilling down is very time consuming and it can be inaccurate because you are relying them, not on independent data, you are relying on what poelpe are telling you, they may not always telling the truth.

Interviewer: Can you clarify the drilling term. If you have an AI system, when you drill down and the AI can make cross-references to identify the issue?

Participant: Absolutely, in a mature environment, a really good AI system has up to date data and accurate infomration and it has intergrated information, so shall we say, physical progress, resource, cost and yes physical progress must also somehow be a reflection of it's not just widget. A has been deliverd but widget A that has been delivers is fit for purpose. So that then says that you got to have an intergration of your management or assurance processes so the quality management supports physical progress trackin, does that make sense?

Interviewer: Yes it does thank you.

Participant: Which is where tools and techniques like earned value works very well.

Interviewer: If there would be such a system, the matutiy is good enough to implement this, where do you see the "low hanging fruit"?

Participant: Sorry what do you mean?

Interviewer: Where do you believe "the AI" can make a difference? If a refer to Levitt & Kunz, areas which they suggested AI can have a difference in project management: objective setting, project planning, project scheduling and project control. Of course there

can be many more and you are free to answer in any way you like, you mentioned assurance for example before.

Participant: Yes exept that of course, well assurance… I know it is kind of dissapointing about our wonderful profession, is that it is much after (behind) science. APM definition, it seperates governance and assurance and I quite like the definition because it is quite an easy one. Assurance is something you do inside a project or programme to make sure the project or programme is managed affectively, it is how you assure that. Governance is what you do for a group of or a project from project or programme. Does that make sense? So that is we you get sort of organisaion, goverance, it is how you for example approve budgets for projects and programmes. So it is that approach when you go to the board and get the money, governance procedures. And assurance, "you got the money, now go and spend it wisely". There is, all of these (objective setting, project planning, project scheduling and project control) are aspects of assurance and objective setting will absolutely link back into governance – why do you want the money? It is the why? And this (project planning) is how are you going to prove to me that you are going to spend wisely. What I cant quite remember is what they made the difference between planning and scheduling. I can't remember what they said. Some people say project planning and project scheduling is the same thing.

Interviewer: Yes so I define project planning as before resource management, project scheduling is the step after resource management.

Participant: Okay right, that is what I thought. Those (project objective and project planning) are the two that probably link back into governance, but they all work at the assurance level. Because they are about an individual project or an individual programme. There are a lot of other stuf you can wrap around that. You'll be familiar with the time, cost and cost pyramid.

Interviewer: Yes I am.

Participant: Okay, now my version of that is not just this, it should be these days a pyramid. The four things that define any project are the time, cost, quality, requirement and then people. Because you have to define how to deliver that project, what's important to you. And you should put some defniniton around how you are going to lead it and how the team is supposed to behave etc. I have increasily starting to think that, and yet most best practice kind of says "oh yes that is kind of intersting", and leadership, stakeholder management team building, behaviours, have kind of becoming more to the forth, but to me they are critical, beceasue it is always people that deliver it (projects). That is also on most on the papers and stuff that I've read the last few weeks especially around AI, most of them deal with what I call the "hard" opposed to the soft aspect of the profession. And that is the procedure, the data, and the tools

that support them, rather than the people that make it happen or get it in the way. That is another thing I am writing is “how to kill a project”. And the basic answer is most organisations don’t even have to try, becaues emost PMs spend most of their professional lifes struggling to make their projects to live within an organisation that wants to kill it. Not deliberatly. A quick example, you get someone like XX organisation, almost all of their field activity is done thorugh projects and programmes and amnagemend throguh huge portfolios, multi billion portfolios. They are a project based organisation, they have fantastic mature procedures, they have fantastic specified levels of PMs and capabilities. You can’t run certain types or sizes or complex project unless you reach a certain level, I think they have four levels of PM, so they won’t trust you until you (individual PM) reach a certain level. They make a great use of AI, nothing like as far as they could go, they are an organisation amongst one of the most mature in every aspect. The organisation is built to support projects and programmes and portfolios to create an environment to which they can thrive and not only survive.

Most organisations, even big organisations, that might spend 30/40% of their annual investment on project based activities, sometimes they know it sometimes they don’t, are not set up for that. For example, the BaU, how you get things financed? I’ll giv eoyu a quick example, take a major change programme the number of organisations gone into, where you have a three years tranformation programme, every year that programme has to completely redo it’s budget, which meant the top level project managers, let’s use the PMs, had to spend at least two months, a huge amount of their time, 2-3 months each year re-visiting and re-submitting completely back through the company annual budgeting process, instead of the organisation saying “we regonise this is all modifying aspects of their finacisal governance to say “we know we have som biog change programmes and when we approve on board level a change programme and a budget for that change programme, that’s it. Unless something happens in the performance of that programme, or something happens in the environment in the business that means there is is massive down turn e.g. 2008, that means that need to do something, that programme has its’ budget and it does not have to come back before the year and say can we please have that money again. And that happens again and again and again. That is just one way AI can help.

Resource management is another example, where projects or programmes say” okay we regonise you need a number of experts from the business opertations to do your projects, and all your scheduling is predicating on getting those resources. No company has people sitting around with a lot of spare people. So you get someone who is a team leader or department manager who is told: “if someone wants to take their best people away from them, well what is that going to do to my performance or annual bonus?” “No you can’t have those people”, so that is where the human factors get completely in the way of projects and it doesn’t matter what procedures you have, doesn’t matter who has approved and is saying you know “I am a director

of such and such silo operation, yes you can have those resources", unless they physically make it happen and then working with the people to make sure their day to day operations that still happens in a huge percentage of otherwise very good organisation. Projects are not part of BaU (code as humans factors come in the way for efficient resource management). And therefore project have to fight for survial, so it doesn't matter what AI you have when it is the human factors and the organisational factors are mitigating against the success of that project so AI to be successful it is not just the project programme and portfolio management has to be mature but where the valute can really be deliverd is where the organisation adapts its operational and goverenace processes in order to be supportive to project, programme and portfolios. That soesnt have anmae broadly, there is a small group of us, we call that organisaitonal project managemet, it's hpw do you create an envoronment in which proejcts can thirve, someone like XXX does it. Most of banks don't for example, governements certainly doesn't.

But that is critical to AI, so this all perfectly works it also needs to be integrated as you say the resource management in particualr coming through but there is also when you do scheduling other things are coming through, so there is stakeholder mgt, communicatino ,planing, quality managament, quality planning, and intergrated project or integrated project plan will have physical fincanicals, quality related aspect and also usually stakeholder and communication related aspects.

Interviewer: What about project control, can you expand your thoughts on AI and project control?

Participant: What do you mean with control?

Interviewer: Basically when the project executes or deployment, but it can be any control of project acticities if you prefer that definition.

Participant: Oh okay, well you need to control your project, I guess this is similar to assurance really. I'd say you can replace assurance with control for that matter.

Interviewer: Thank you, I understand, so what about when the control or arruance goes wrong and the project escalates, what happens then?

Participant: Well then we have to go back to the drilling down process and find what is actually happening? Some may be reluctanct to take this decision but it is necessary and is part of best practice I try to implement.

Interviewer: How do you the project manager role to change in the future, in 20 years for example?

Participant: I'd love PMs to be primarily leaders and to be spending 90% least of their time, creating the right delivery environments. So it's the team building, getting collaboration working, working on the personal basis on 3rd party suppliers. That is where I usually set out to do, usually set out to create a maturity around an integration of people processes and tools. By peolpe I mean the organisation roles and responsibilities as well as the behaviour the people are doing. And I like colloborative teams, but I also wield a baseball bat to suppliers if I need to. But is it recognising what enablers are needed and that might vary at different times during a project as well. So where I would love to see is two things: I'd like to see organisations creating that environments in which projects can thrive, which means all of the processes, the AI tools but all fully integrated in the rest of the business operations.

Interviewer: Do you see AI having an important role?

Participant: Huge, a huge role. Because it should again, if I may, most papers I have read talks about release of time, saving one way and stuff. We did it in a vary, my peolpe in the past have done it a very prmiitve way, using spread sheet etc. That was very primitive, you can do that much more smartly these days and far better these days, but you got to have that maturity and you can do it, in a fairly limited way just within individual projects. We can do it within the customer project areas within XX (specific department) because we basically control everything and the only interfaces we had where at a summary level with the financial systems and I had one person within the enterprise project office that did that on a monthly basis so that was quite easy to do. And then we had a dashboard we created for the board (executive/senir mgt) every month that said what the physical progress of all the customer projects were and also what they really liked how much revenue how much the projects had eanred in a given month. But these days you can do that so, so much better, and if the various systems where integrated, and given, as a said the infrastructre technologies, even remote workers, can link into the system. It works both ways, so automating, updating, automatic chasing – "you got a milestone due", "there is a mitigating risk, mitigiton task for you to complete", "you have to do that for the next few days, you need to do within these certain days".

Interviewer: Is it close to live data reporting?

Participant: Yes. And the bit you also talked about here (knowledge mitigation), that is potentially huge, being able to look at trends of data. Because again, in the past I've had that done, but is has been very difficult and quite labour intensive to look into milestone trends or even just red, amber green rag trends, so we've had gey milsteones being green, green, green, amber, amber, amber, wow wait a minute. We got a trend toward things not going so well, that has been very labour intesive in the past, the ability to get underneeth that with AI systems, and not only to use those trends views but to get access, easy access, down into the data, to quickly

understand why that is. Is enourmous but you need the maturity of the project, programmes and portfolio mangement and that includes peoples' ability to behave in the right way. For me the big one, and the most difficult, is how to integrate into and create a supportive organisation.

Interviewer: Do you use historical data or only newly generated project data?

Participant: I want as much new data as possible in the AI model, the data used for planning is important, but using the new data [project data generation] makes me trust we use the most relevant data [trust in AI model]. The more current project data we use for the AI analysis [project data generation], means I will have in the model and I will be willing to act on the AI analysis [trust in AI model]. It is unfortunately not possible for us to feed the AI with live data, so we have different perspectives to say it nicely sometimes [information asymmetry] [misaligned goals and objectives]… So its not always relevant to listen to the AI [override AI bias]. Myself and the team are essentially not aligned with the AI [information asymmetry]. Let me calrify. So its not always relevant to listen to the AI. It results in a low trust in the AI [trust in AI model].

Interviewer: Can you expand on this?

Participant: It is different depending on the context and the historical perfromance of the AI, but I rather use the data that is created during the project [project data generation], than data that feels outdated [cognitive anchor to data]. To be clear this is in best case, sometime we only have previous data but if live data is availbe I will use it, if its of quality of course.

Interviewer: I've come across AI interpretability and trust in the AI output is good?

Participant: Well the more trust I will have in the model [trust in AI model] and I will be willing to act on the AI analysis [willingness to take corrective action]. It's quite simple like that, but if your organisation is not mature it won't be easy and you shouldn't even have that issue. But again interpretability is only an issue with machine learning, not with expert systems. I try to only introduce these tools when the organisation is mature but the issue can still remain, and it requires some carful consideration.

Interviewer: How about the individual project role? In the future do you believe the project support role will still exist in 10, 15 or 20 years?

Participant: Hm, it is a tricky one I would say. You may be aware of that the APM defines 6 challenges for the future project mangment, where AI sits within, which I thought quite fascinating. But if I was looking at roles for the future, I would say that the future professional is more of a people person than a technical. Becesaue the AI should be able to do a lot of that. There is a caviat upon that, the PM still needs to understand the risks and schedule and understand the cost sheet, but for me I would love to see the profession, so the top

professionals, in fact it is what the top people are now, they are basically the people saying "you know we can do the basic stuff, this is the relatively simple, the mechanistic stuff, that should be easy. The difficult stuff is to make people to do what you need them to do and stop people doing from what they shouldn't be doing. And I love people to have the space to do that, and when again I've gone as a consultant, remember I started with people saying "oh why should I use best practice, it's all very good in theory. No it's all very good in practice." Because if you follow beest practice, it's not a "cook book", it's a tool box there to be adapted, which is also why I said the best proejct professionals are agile, because being agile mean adaptive. So I say you gonna understand best practice and have experince of in order of understand how and when to adapt it to the need f an organisation or to an individual project or rogramme. Once you got that technical (PM) knowledge, where most people are going is how they are dealing with stakeholders, how they are dealing with team members, how they are dealing with their counterparts, how they are dealing within th eorganisation who they are trying to get resources of, maintain relationships, and again to me AI is critical as an enabler to allowing professional to become more and more "people – people".

Interviewer: How technical should we become in AI?

Participant: You shouldn't need to become too technical but to understand it.

Interviewer: I would like to ask about the term complex project. Do you have experience of this?

Participant: I like to keep it simple, I don't believe in complex projects, there is no such thing as complex projects. A complex project is a programme (does my definition of complex projects have to change? Practitioners say "there are no complex projects". A conceptual framework for tackling knowable unknown unknowns in project management. I suggest to read "Ramesh and Browning" a conceptual framwork for unks-unks. There are no complex projects, only "complex management". It is project management, it comes back to the iron triangle, the purpose of the iron triangle was to say every project can be defined through the three peramaters. For a certain cost, budget, you are going to deliver a defined set of deliverables within a defined time. That is exactly the definition of a project and it has been like that for 50 years, since 52 years since the iron triangle was embedded. As soon as you, what happened in the 80' and 90's was that you got more and more uncertainty. More scale of project scope and more uncertainty. For transformation to happen in one year "this could take 18 month or 2 years or what ever". And we know in general what we want the outcomes to be but we don't know specifically, and that is why programme management was inveneted. Move forward to 10, 15 years ago, people started to talk about complex projects. I went to a lot of talks and seminars where people were talking about the management of complex projects. And they ususally had a book to sell, this is what

the management complex projects looks like. My hand went up and lots of others' went up asking "excuse me isn't that the same as programme management?" So complex projects are programmes, you don't need to reinvent anything, programmes management was invovled to manage things that have complexity and or uncertainty ususally both. Even if something is fairly small you can easily adapt programme management because it is mainly the way programme management works, it is set up to deal with complexity and uncertainty. It combines the mechanisms to do that. But unfortunately, a lot of people have a book to sell.

Interviewer: So you suggest that I shouldn't use the term complex projects then?

Participant: Well there is another dimension to it. And that is in fact I am an assessor for practioner certificates, the precharterd status for the APM, and one of the common areas we explore candidates understanding of what project complexity means, because you can have a project which is technically complex, like building a power plant, but building a hospital might be technically challengable but in management terms the people who built hospitals have built hospitals before, so it is not a complex project.

Interviewer: I come across that people confuse complex and complicated projects.

Participant: People confuse the two. People say "I run complex projects" what do you mean? Tell me about your management challenges, and then they say "well actually that was quite easy".

Interviewer: Would it be possible for AI to mitigate the complex environment?

Participant: Yes. To try to keep it simple from my point of view, leaving aside technical complexity, looking at something at managerial complexity that has high uncertainty or just high management complexity, I don't actually care whether it takes and adapt PM or Prog. Mgt, they should come and look at it and say how much am I going to bend this. Personally, if someone told me, "I want you to go and establish the assurance of this thing which we think is managerial very complex", I would probably start with programme management and see how I can adopt that. But actually if they said "look this thing has a lot of management complexity but fairly small but just happen to have a lot of mgt complexity" I would probably start at PM and start thinking how can adapt the procedures and maybe later on what ever I need to manage the complexity. Here AI can come in. For example you might have multiple competeting stakeholders, or multiple suppliers so your supplier mgt might be the tricky area, and at that case it might not matter whether you start form PM pr prog mgt, but you are actually looking at and saying what do I need to adapt and what are the mgt complexities and challenges and what are the best way dealing with that. Again, that comes down to having a good professional who knows how to

adapt. And focusing on the management challenges and looking at the best ways to adapting to those challenges. Does that make sense.

Interviewer: Yes it makes sense.

Participant: And where AI comes in on that is trying to keep things as siple as possible because you have high level or mgt complexity, what that ususally means is that you have to put in more mgt effort. As a "ball park" that says 10% of your total effort and cost of a project or programme might be the project management and then rest of it is all the technical aspects of it. If you have something that is small and managerial complex, that might be 30 – 40 %, because you need that amount of overhead (extra effort) in order to mitigate the complexity. Does that make sense?

And that level of management could be people oriented, could be lots and lots of stakeholder mgt or an awful lot of measurement, an awful lot of detail planning and very tight control process and data, and that's where AI will be critical. (Projects are not complex, the environment of data rich environment are complex).

Interviewer: That is very interesting, I would like to have some follow up questions, let me look in my notes.

Participant: I am very happy once you start looking at this, you can ask we again, over the phone or email that is just fine.

Interviewer: I come across a discussion where people say the human element is the most valuable element a project manager can provide. And organisations can today use chat bots for some simple management tasks and it also can ask employees to express theire mood, happy, sad etc. Whats you thoughts on this?

Participant: Well, you say it's the most valuable element it was almost completely not recognised 10 – 15 years ago. It was almost as if it was a hidden thing, it is somehting almost every project professional knew but none ever put it into to the literature.

Interviewer: If this oragnisation is happy managed by a chat bot, is the human element as valuable for everyone?

Participant: You mentioned the chat bot asks "how you are feeling?" Two things, first of all, if that just being used as a humanising trick by the AI system to sort of make people more comfortable to interact with a chat bot, I find that quite annoying. If however, there is a response coming back saying "I am actually feeling good what ever", or the chat bot asking for specifics and then it has some sort of measurement, I think that is really useful. And I'll tell you why, in the

very simple monthly report we used to get back from our customer facing PMs, we almost asked them to talk to their clients and ask how are you feeling on a scale and why. And that would translate into a red, amber, green, and that would go into all the other measurements. And specifically that would be feedback to the sales team. So if we had a client say "well I am feeling things are going okay, but I am not terribly happy and this is why", so then A) the PM would say is there anything I can do to help and if it is then out with what the PM can deal with then it's the sales person to get straight back to them asking how can I help, what's going wrong, what can we do to make it right? Beceasue that is about winning th enext contract. So we would collect that and we would keep those, you know they are very, hm, informal measures. They're not really metrix, they are anectodotal but none the less we translated those to red, amber, green and we could track that, you know is this relationship looking good or is it strtaing to look rocky, does that have to do with the product or with the product we are implementiftng. And that is somehting AI, if it's set up in the right way, looking for the right responses, it could track that, it could track behavours as well.

Interviewer: Thank you, I don't have any thing more to ask, do you have anything to add?

Participant: In summary, the two key things that will either stop AI being used or really enable it is the whole behavioural, the people side of things and the organisations creating right environment. At the end of the day, the evolutionary best practice and the evolution of tools and underlying infrastructure have been fantastic, but the average performance of projects right across multiple industries' failure rate still varies between 40 – 70%, and that has barely changed in 30 years. And for AI to be valuable, it got to bring that down to more like 20%, which is more like average wastage in manufacturing or almost any other operational management. (the second key thing is maturity).

Interviewer: Considering this, will this failure rate every decrease?

Participant: To be fair there are factors that led to increasing challenges in project success. And that is the whole area around the frequency the sheer level of number of projects, the size of them, the complexity of them, the uncertainty of them, all of those factors which can kill projects and of course the more project activity there is in an organisation that is not supportive to project is going to act to kill projects. Which is why I am writing this "how to kill a project" you know.

Let's say there is an effective AI in a PM organisation, will the failure rate really decrease? If the efficient system is available won't the number of project increase and work load increase as well and there won't be decrease of project failure?

Participant: So to me there are two key factors that can enable that 40% or 70% to get down to more like between 20% - 40% depending on the company and the sector etc etc.

Session 2 December 2021

Interviewer: I have some follow up questions, would you say this is an accurate causal chain? (sharing screen and showing causal chain). It is about the confidence the project manager has when acting on the RAG by the AI analysis. My hypothesis is that PMs are less flexible and has more confidene in the project plan leading to more escalation of commitment and not taking corrective action. We have other variables here as well (showing uniqueness, explainability).

Participant: I understand, well let me have a look…. I would say so since I have to adopt and adjust the project when we have new information [cognitive anchor to data], and yes I will, if necessary, change the set project plan [confidence in original project plan]. If I have confidence in that the project plan is well made [confidence in original project plan], then I will probably have more reluctance to do anything about it. I would then want to give it (the project) some more time [escalation of commitment]. When we identify tasks that we need to redo [project rework], it will obviously be a risk that we don't keep our deadlines and schedule [project overruns].

Session 3 – February 2022

Interviewer: I have now added to the causal chain, partly based on our previous chats. I have added anchoring and additional loops here. (sharing screen)

Participant: Yes I studied them, I think this is very interesting.

Interviewer: Do you have any other comments or do you react on this?

Participant: I mean it all depends right? What is the boundary of the model?

Interviewer: Yes exactly. Here the boundary is the project manager acting on the warnign signs of the AI and has to decide to take corrective action or not. There is also an element of trust here which I have through about and made this causal link.

Particiapant: Yes so based on that, in this context, you gave me context already, I think is very interesting. There are some unique areas in every project, sometimes the team and I overestimate the value of these unique traits [project uniqueness perception], sometimes we don't, but when we do it affects how we interact with the AI and if we can be sure its fed with relevant data so we can trust it [trust in AI model]…. I then may choose to follow the team's analysis if it is not aligned with the AI [override AI bias]. The better the explanation is [AI

explainability] the more I can believe its output is correct [trust in AI model]. If not, it will be difficult for the team and I to justify follow the AI [override AI bias]. The reason for why or why not I am trusting the model [trust in AI model] can be based on many different things, being able to explain the model is a major factor [AI explainability].

Interviewer: I appreciate you taking the time again to talk about this. It has been vary valuable for me.

Participant: No problem, it's very interesting. I am big in agile as you know and I think this can work in this area too, let me show you some stuff here.

P12 February 2021

Interviewer: They people have different interpretation of artificial intelligence and but I'm just interested in your personal experience and if you have any exposure of data within projects. And when I talk about 'data' it could be a wide range of information in that sense, it doesn't need to be hard-coded data in that sense, so it could be information in general. So we try to use as common language as possible. So qualitative interviews today, Do you have any question before we begin?

Participant: No, that's fine. I'm happy to participate and share my experience with you.

Interviewer: Great. So yeah, when I talk about 'big data' I mean simply the three first Vs that were defined as big data and I refer to volume, velocity and variety, and this can also be interpreted in a different way of course. I'd like to ask first what's your experience of project management, shortly, just a few minutes to discuss what's your background in project management so I can just contextualise that.

Participant: Okay, so my background in project management is that I've managed a number of projects, both technical projects and human resource projects, over the last 25 to 30 years. In particular the big Information technology projects I've been involved in the development of a new command and control system for the Royal Navy for the development of a national ship-building approach for the development of warships and aircraft carriers for the Royal Navy. The human resource projects that I've been involved in over the last 20 or so years, I've been involved in the development of skills across government where I was the skills champion in the Cabinet Office for developing skills strategies in government departments. One of the most recent projects I was involved in human resources was to develop a strategy for recruiting nuclear-qualified engineers for both the Royal Navy and for commercial nuclear projects where I needed to manage a lot of data related to some of the recruitment challenges and the retainment challenges with nuclear-qualified professionals. And I've been involved in a number of other projects since but those ones are probably the most significant ones that have exploited considerable amounts of data in coming up with strategies and implementations based on that data and AI.

Interviewer: Thank you. Okay, so you've been involved in projects with data obviously and… I mean, can you define the technical project, technical as in technical with computing and software or technical as in project management technical?

Participant: Technical and technology in terms of hardware and software and complex in terms of the amount of data and complex in terms of the appropriate project management tools to be used in managing and controlling those projects.

Interviewer: Okay. Thank you. What is your experience of AI and this kind of analysis?

Participant: Yes these projects have systems analysing data in form of analysis which we had to act on. Different status for the team to act on.

Interviewer: You mentioned management and control systems, was the AI used for project control?

Participant: Yes and no, well not only controlling the project, it was used for identifying risk and finding best solutions. It was really interesting to see it working in practice and it was a great school.

Interviewer: Okay, if I may ask a straight question about the volume of data. What's your experience in the volume of data you've been exposed to, has it been manageable or and in what way have you been exposed to the volume of data?

Participant: The volume of data that I've been involved in with some of those key projects that I've identified has been about the amount of data within management products, such as technical specifications, user specifications, design specifications, and being able to ensure that the right people have got access to the right information when they have needed it. In the sense of the work that I was doing in making sure that we had a supply of nuclear engineers to meet the requirements of the Royal Navy in the future and for civil nuclear power station projects, that was related to information on individuals, their qualifications, what they were doing at the moment, information about their levels of competence, kind of human resource information. So to a large extent the data has been about people and the data has been about what was captured in management projects and management products that will enable those projects to be managed and controlled effectively.

Interviewer: Okay. Thank you. So within these projects have there been data that you wish that you could have accessed or have you been satisfied with the volume of data that you've been using?

Participant: I've been satisfied with the amount of data that I've been using but it's sometimes taken a long time to get to key aspects of information that is contained within the management products. For instance, looking at detailed requirement specifications for complex technical

projects, it takes some time to identify the appropriate data and to retrieve it and then make sure that that data is protected so it always represents the latest version of the hardware and software that's been involved in the project. So the management challenge with data has been about retrieval usage and recording more than any other challenge.

Interviewer: Sorry, can you repeat that? You said the challenges were "retrieval"?

Participant: Retrieval of the information, making sure that the information is recorded properly and updated properly. So the management of information really was the biggest challenge and that had a relationship in terms of productivity, the time it takes to process the data.

Interviewer: I might come back to that with some follow-up questions. Before that I'd like to cover different structure of data. Have there been different types of data/information that you've been struggling with managing in that sense or have you experienced that this hasn't really been an issue?

Participant: Can you just categorise the types that you're talking about with variety?

Interviewer: Yes so it could be, for example, you have data free text in a Word document as simple as that, and then you have reporting which maybe best practice documented in very structured data. For example, for a project manager it might be a challenge to incorporate this free text data you have in maybe a risk register or general issue log and how to identify that data and define information that you need by the right time. So has that been a situation you've come across and has been a struggle or has that not been an issue really?

Participant: I think of it as two issues, if I could identify the two key issues... The first issue is about the consistency of language that's being used in capturing information within specifications. And if we stick with one example because it makes it easier to understand, if, for instance, we're talking about, say, a requirement specification or a risk register, consistency of terminology being used in those kind of management products has been variable, which has caused more time in processing than would otherwise be necessary. A lesser challenge is general use of free text in reports where the essence of the information that's required to be conveyed has not been clear enough so there have been ambiguities introduced because of the language used to explain a situation or an occurrence of anything. So the kind of verity of things has led to misunderstandings and more time on the processing of that information than would otherwise have been the case, had the information been codified in a more consistent way, if you understand what I'm saying.

Interviewer: Yes. Thank you. How is the process of you gathering data in velocity, as in speed, has this been an issue for you to gather data in the right... what's it called... in the

right time and the right speed that you wanted to. What's your experience there? Do you understand my question?

Participant: Yeah, I see your question in two parts really. My more recent experience with project management in terms of the data that I would be using for management and control has been helped significantly by the use of software tools and by the use of templates because what that's done, it's organised the data in a more consistent and easy to process form, in a shorter form, in effect. The other aspect has really been about, as I reported in that previous question, ambiguities that I've seen in the way that details are described has just caused more delays and more time in management than would've otherwise been the case, had that information been organised more effectively. Does that answer that question that you asked? Do you want me to go through that again? Did that answer the question that you wanted?

Interviewer: I can ask a follow-up question. Have you always been accessing data through a stage process or have you tried to target a more live stream data in that sense? What's your experience there?

Participant: Really a combination. Most of the live information that I would've used would've been through verbal reports, through meetings, through verbal updates that have been provided by project team members. Otherwise the information that I would've used would've been recorded information.

Interviewer: Do you see that could be a benefit to use live data in a project environment?

Participant: I can see that there would be a benefit in using live data if there were some way that that data could be translated into a form that could be reliably processed. So in the same way that we might use key words and key phrases in trying to manage information within specifications, trying to use some kind of tool that might be able to abstract key statements, key pieces of information from a verbal report, if that could be done that would increase the efficiency of management and it would reduce the number of errors through misinterpretation.

Interviewer: If you can choose between historical data and newly generated data, what are your thoughts there?

Participant: It goes with what I said before that sometimes it is difficult to find and identify appropriate data for the specific purpose. So then historical data is sometimes better because it is proven to have the quality we need. But live or new data is more up do date so we need both.

Interviewer: If you had to choose between one or the other, all else equal I mean.

Participant: Well then I want the newest data, it will most likely make the analysis perform better. But this is not always the case as I said.

Interviewer: What do you think is the challenge for this to happen, for having more current data?

Participant: I think the challenge is to have a capability whereby a system could process words and abstract the key points from what's being said automatically. In the same way that we can process an image and derive some meaning from an image, if we could have processing that would derive the most important meaning from what's said then that would have an advantage in terms of speed of decision-making and accuracy and lowering error rates through misinterpretation.

Interviewer: Interesting, can you expand on your thoughts of decision making and the relationship to AI and data?

Participant: Wow yes that's a big question. I think we can do much better in this area; at the same time, it is extremely difficult to always get it right. I see AI and data as augmenting tools and information for us to make better informed decisions. As a another perspective. We need to collaborate with AI and understand what data to use in order to improve our decision making.

Interviewer: Thank you. I hope we have time to get back to this topic. So you mentioned previously when you talked about the volume of data that it was.., Sorry, I can't remember exactly what terms you used but have you experienced a large... not volume but in general have you experienced data that has been unstructured in that way that you haven't been able to use or have you been mostly exposed to structured data in that sense?

Participant: A combination of both really. Where the data has been structured and it's followed good rules then that data has been more useful but in many instances I've tried to process data that's not properly structured and it's taken a lot longer to make sense from the information related to that data.

Interviewer: What about the structured data, have you always been able to incorporate data or have there been any situations where you took a decision based on your personal experience instead of the structured data that you had available?

Participant: There have been instances where I've used experience and intuition to complement the data that I've been provided with but as a project manager I've always tried to base my decision-making on evidence of data. Even if it's not making a decision on the data, complementing the data with experience rather than intuition based on no data.

Interviewer: Because I've come across a lot of practitioners talking about the human element and in the end it is people who deliver projects and I come across consultancy organisations who really empathise that there are human values they bring to organisation. So considering your situation, you always try to complement your experience with the data and do you think this is the best practice among other project managers in general? If you talk about the cross-industry, the typical project manager, how do you think they act?

Participant: I think that's probably quite typical that an experienced project manager would use data and use the evidence and then add to that data and evidence by using their own experience and track record in what that data might be leading to. And that would be probably a quite common thing with experienced people where actually there is probably more value to be added to that data by what the experienced person, whether it's a team member or a project manager, may add. What I would note, though, that a lot of the personal interactions in project management come from meetings and engagements where individuals report on what they have been doing, the progress they have been making and the challenges that they've found. Where that has been improved is where individuals are provided with a clear template of exactly what they are requested to report on rather than individuals free-playing what they report. Accurate reports where I am given the status of the project [project progress] are key for me to be able to make an educated decision whether the project needs correction [corrective action] or not. When I am given accurate reports based on current data [project data generation] I feel more confidence in the (AI) analysis [trust in AI model].

So in the same way that good project management is based on structured reports with the key points then being discussed by the governance arrangements, my experience tells me that the same thing applies to verbal reports that are provided by individuals, that actually that should be organised in a more effective way to make sure we get the maximum value out of what's being said and what people know, which would make the decision-making then much more effective based on that information. We have learnt that all projects are unique [project uniqueness perception], and its true to some extent, this perception makes me question what data is fed to the model [trust in AI model] and if the model's output is useful or not.

Interviewer: Thank you. So I'd like to also ask questions about the project lifecycle and this research is cross-industry. So in what stage of the lifecycle would you say you have experienced most. If you use structured data as the data that you've been able to use, in what stage of the project lifecycle would you identify the area where you have been able to use the structured data mostly?

Respondent: Probably in the early stages of a project lifecycle, so in the concept and early development phases would be the areas where that has been most important having the data.

And also sometimes later on in the lifecycle when the product project deliverables are in service when it's necessary to introduce changes to the product because of the environment around the product changing. So early in the lifecycle with the available data then dipping down through the back end of development and production, and then at some time in the operational usage of the project deliverable it's starting to come up again and then that being important then as a challenge during the in-service life of either the equipment or the service that's being provided.

Interviewer: Okay. So in the early stages of a project lifecycle, you said?

Participant: Mm correct.

Interviewer: And where has this data you used there come from, has it been used from historical projects or has it been gathered for this specific project specifically?

Participant: In practice I see that the majority of information comes from the generation of the ideas and the concept and the plans around that specific project but some information being drawn from learning from experience and from comparative analysis and from other sources where benchmarking perhaps or other sources of information has been fed in to help the early development of the management products for the project.

Interviewer: Okay. So if I asked what areas of the lifecycle you have been able to use it, can you also define what areas you haven't been able to use the data where you wish that you would've been able to improve projects and data management process?

Participant: I think generally through the lifecycle there's always been a need to make sure that the information is recorded, disseminated and updated effectively as kind of almost like a baseline level of capability within the project. As I've indicated, I think the bigger challenges have been early on in a lifecycle, in concept and early development. Another key area is when the delivery of the project is starting to happen and acceptance activities need to be verified against baseline acceptance criteria where there needs to be clarity in what the project should be delivery and again then later on, as I mentioned, in the in-service life of whatever it is, the equipment or the service, to make sure that changes and upgrades can be made effectively and for that baseline to be still maintained. One of the practical problems that I faced is that during the project lifecycle a lot of attention is usually given to making sure that the record-keeping of the information is as good as it should be but when the project finishes, generally speaking, the interest in maintaining the quality of the information then falls away so that when changes are necessary to whatever project it's more difficult to get to the information once the project is actually completed because generally the organisation is trying to manage that project information but there's no team left to be able to do it. So it's invariably been done by some kind of project management office function or even simply by admin support who would, you know,

dig out records that might help when one is trying to ascertain whether a change to the project in the future is a sensible thing and whether it's justified under the terms of how much it's going to cost to make changes.

Interviewer: So to ask a follow-up question on that specifically, how could that be improved? I know you've mentioned that there's a PMO office so do you see that this is best practice and it should be in this way or could this data be used more efficiently for future projects?

Participants: I think this, that the important thing in managing a project, both during its lifecycle and beyond, is that the integrity of the information is as good as it can be, and for the integrity of the information on the project to be as good as it can be then there should be standards of organisation of data that should apply throughout the lifecycle. If those standards of organisation of data are maintained then there is more efficiency within the project management approach in general and it's easier during the in-service operational life of the project to be updated if the data has been organised in a specific way to set standards. Generally speaking, there are big opportunities to ensure that the standards of recording in the reports are improved and the more that those standards are improved, the more consistency there is in terms of understanding and the more ability there is therefore for the data to be processed and decisions to be made on it. And if that template can be taken to the extreme where it's organised in such a regular and consistent way through the lifecycle of the project then it is possible, if the right language is used, for non-humans to actually process that data, but only if it's organised in the right kind of way.

Let me just take an example. The most regular and defined aspect that you will find generally in a project will be the detailed description of the smallest items that are used that comprise the project, what you know as a configuration item. Configuration item, the lowest common denominator. A configuration item is detailed in a very prescribed way; it has a unique identifier and all the statements about its characteristics are simple statements. Those simple statements don't have to be processed by a human, they are organised in such a way that they can be processed by other forms of processing. But the higher up the hierarchy of documents, the more complex the language, the richer the language becomes and the more difficult it gets to imagine that anything else other than an experienced person can process it unless the data is organised in a way that is consistent.

Interviewer: I am, thank you.

Participant: But at the moment I can see the… So if, for instance, we're talking about a configuration item – it might be about stock that's included in a warehouse – then you can see

quite easily how that configuration detail can be processed by other than a person because there's easy to interpret characteristics. As we move up the hierarchy of the documents, so we go to an issue register, a risk register and other communications records and various other records, the regulatory and consistency becomes more complex and there lies the challenge, I think.

Interviewer: Okay, I understand. So using your analogy then at the configuration baseline, at the bottom it's very structured data, if I understood you correctly?

Respondent: Yes, it is. Sorry, I should have used that word, 'structured data', yeah.

Interviewer:Just so I... Yeah, no, you can use any words you like, just to make sure. And the higher up we come, the more unstructured it becomes?

Participant: The likelihood is increased of it being unstructured, yes.

Interviewer: Interesting, and why is that?

Participant: It's probably because the requirements from organisations aren't so prescriptive at those higher levels of management product. It would follow, as you know, organisations would probably just use best practice to make sure that the information is captured. The main driver is to make sure the information is captured but not necessarily organised in specific way, so the challenge is then trying to see if there's a level of importance of additional structuring that could lead to efficiency if that investment was made early on and as part of the project management requirement to structure that data more effectively. Some organisations do, some organisations don't.

Interviewer: I understand. So if I also may ask would the project methodology used approach for the organisation, could this have an impact on this, do you think?

Participant: I think it might provide the right context. If one uses a project management methodology it's more likely that you'd have a context where you might see the benefit of better structuring. If there is no real methodology that's less likely to happen. I don't think the methodology in itself would give you the structuring that you need because the methodology would be simply saying, "We need that information" but not always in a specific form, unless there are lots of different templates. The use of templates is a really good way where you can build the structure in.

Interviewer: Okay. So if I might ask a straight yes or no question. I come across the opinion of agile is the key element in adopting for complexity but could it also be hindering the structure, the people structuring the data, if people make that "We are agile, we don't need

to have specific structuring in the methodology" and that will affect the data? Am I understanding those two correctly or what's your thought there? Do you understand my question?

Respondent: I think there is a risk that when we use agile, which clearly offers us lots of benefits, one of the disadvantages might be that it's less likely that we would be able to incorporate the kind of structuring on the data that might give us the efficiency benefits of using other forms of processing. So I think it's a dilemma. Agile may be good in some instances for the management of particular projects. It might not be so helpful in terms of finding ways of automating some of the functions of project management, where a strict methodology that's based on templates, characteristics and a framework would encourage more use of a strict type of language that could then lead to automation. I think it's a dilemma; I think agile is great but there are some disadvantages.

Interviewer: Would you say the methodology would impact the decision-making process with the control AI system?

Participant: Interesting question, maybe, or probably. Also depends on the people, but with agile you will have more adaptability than with a "slower" methodology. But still it depends on the project.

Interviewer: Yeah I understand, you can't draw any conclusions, you can just speculate what could be an issue there. I don't think I have any specific questions about those things you just mentioned. I try also to ask more broad questions about the concept of AI, which is very interpretive to different people depending on their experience and what they use in their daily life, in their daily work, but if I might just ask a very open and personal question about how would you define AI, if you ever come across this thought, if you ever thought about how to define it. It doesn't need to be an academic terminology or to a different definition, more about your experience of AI, because it may change over time and it may differ. So how would you define AI today, for example?

Participant: The way I would define AI today is a step change in processing capability that would allow decisions to be made much more quickly on valid data. So AI to me doesn't mean it's something new but it's something that's drastically different in terms of the processing speed and decision capability that can result from its use. That's how I would see it. And can I just complement that?

Interviewer: Of course.

Participant: And I think AI does demand that there must be a standard of structure in meaning and information and that would allow for certain processes that are part of project management to be automated and not necessarily carried out by an experienced person.

Interviewer: Okay thank you. And also if I may ask about the term 'AI' 'artificial intelligence', is this something that you use in your work? Maybe not in your work at the university but your language when talking with other people? Is this a term that you come across that you hear people using or is it more of a terminology that you come across elsewhere? Do you understand my question?

Participant: I use it when I'm reported on what some businesses are doing as part of their operational practices, internally we talk about our analysis. So, for instance, if I'm talking about an organisation like Ocado or Amazon or organisations like that I would indicate how they exploit the potential of artificial intelligence in the way that they organise the movement of stock and the picking of stock to satisfy customer orders and therefore using automated equipment or robotics to conduct certain functions. That's where I would refer to it. I don't generally refer to artificial intelligence in any meaningful way in terms of managing projects generally. I would expect to in the future but I don't do that at the moment; it's more about the operational level in some instances that I would refer to it. There are some examples that I might talk to people about where very detailed and complex pictures are analysed, rather than an expert analysing that picture that an artificial intelligence function would analyse that picture therefore negating the need to have that experienced person consuming time to interpret what a picture was saying. So it might be a picture of a defect in a welding operation in a ship where it takes a lot of experience to be able to diagnose whether there's a likelihood of some kind of fracture. Or it might be an example where a medical practitioner might be looking at some form of x-ray or ultrasonic test that might be indicating that there's a problem, where actually artificial intelligence could be used to do the diagnosis of whether there's likely to be a problem, whether it's a cancerous growth or whatever, rather than having highly paid medical experts spending time looking at that picture. So I see there's lots of opportunities but that one is one that's really quite obvious at the moment, and that's not only in the medical profession but it's, you know, in an engineering profession as well that we're seeing that in terms of almost like a quality of a diagnosis. And if we're using artificial intelligence rather than a human interaction then we should see that there's a higher level of consistency and a higher quality of decision-making if it's used properly.

Interviewer: I understand. Thank you. I can't identify any follow-up questions for that actually. Do you have any questions to me?

Participant: No, I don't. All I would also say though is I think there's a relationship between the applicability and the benefits that can be gained from artificial intelligence in project management and the use of software tools and templates that provide a structure in the first place within which data and information is recorded. So basically I'm suggesting that for artificial intelligence to have a part to play in improving project management in the future it probably has to be based on a prerequisite of a structured tool or structured templates that are used from the earliest stages of the project lifecycle and managed throughout the project lifecycle. Without that initial structure provided by a software tool or by templates it's going to be much more difficult to exploit potential benefits of artificial intelligence throughout the life of the project, in both a human sense in the getting the team members and all the stakeholders in the right frame of mind to be much more deliberate and structured in their thinking and recording but also by forcing the structure through the use of fields within software tools and templates.

Interviewer: Okay. Thank you. Anything else? We've almost covered the hour that we had set aside. I'm happy with my questions. You don't have anything else?

Participant: No, I think that's fine, Fred, yeah, I think I'm cool with that.

Interviewer: Thank you. So would it be possible for us to talk again?

Participant: Yes of course, I'd be happy to help.

Session 2 November 2021

Interviewer: Thank you for talking to me again. I have some direct questions for you, still open questions for you to talk freely, but I believe in an iterative process and this is aligned with my interpretable research methodology.

Participant: No problem, happy to help if I can.

Interviewer: So I have refined the research question more towards decision making and escalation. Would you be able to explain your decision process, I have draw an example here with variables "willingness to take corrective action" leads to rework discovery and "more project data" when the system identifies an issue? I will share my screen here, one second.

Participant: I see your screen now. Interesting visualisation. When I act on the warning sign [willingness to take corrective action], I then analyse what is required to do, where is the missing link and what do we need to do to fix it [rework discovery]. This generates more data [project

data generation] for the AI model to learn from. This is almost what you have done here. But you may want to adjust some bits.

Interviewer: I also have other causal links here, escalation of commitment and de-escalation of commitment, also project rework loops with original work done explaining a normal project work process. Also have anchoring as a working hypothesis.

Participant: I see that. Sometimes we make decisions in an emotional state and it seems as we are looking for any excuse to change the plan [confidence in original project plan], well actually, doing nothing is also doing something [escalation of commitment]. Sometimes the circumstances change in our favour." Participant 12

Interviewer: Interesting, can you expand on your thoughts?

Participant: Escalation is interesting we seem to be afraid from it but its bound to happen.

Interviewer: How do you act when your project experience project escalation?

Participant: I follow the protocol. But sometimes it's the opposite of you what you want to do. I know that my project will see some kind of escalation, and it will at first make me hesitant to act[willingness to take corrective action], I know this is a bias all project managers are likely to have, me included [escalation of commitment].

Interviewer: I picked up on a few words you mentioned last time, for example trust in the analysis and unique data. Here we see this. (showing causal chain)

Participant: I noticed this.

Interviewer: Do you have any comments on this or do you think it is representative?

Participant: It's definitely interesting piece. Is this a representation of my thoughts you say?

Interviewer: Well not only yours, it represents project managers using AI for project analysis and escalation of commitment.

Participant: I see, I see. Is it supposed to be a model for optimal decisions, cause then I don't really see it. It is a bit blurry for me.

Interviewer: Interesting, it doesn't represent how we should make decisions, only a representation of the mental models of managers' decision-making. Demonstrating the process so to say.

Participant: I see, yeah okay, I have nothing to add really, then I think it should be good. This is fascinating really.

Interviewer: What about interpretability and explainable AI?

Participant: Yes a great topic. It's quite evident that if the AI offers an explanation [AI explainability] of high quality I will be able to trust it is telling the truth [trust in AI model]. Which otherwise I will not hesitant to go with my instinct and go against the analysis [override AI bias]. This is very difficult today, we use some interpretation models to ease this process but it is not always possible.

Interviewer: Thank you.

P13 September 2020

Participant: No, I'm out of the train now so I'm just walking down the street.

Interviewer: Yeah. Well I'm fine with that, no worries. Yeah, like you said. I couldn't catch what you said previously but, yeah, the research question is quite broad. And I don't want to close myself in somewhere but by having a broad question it also might be looking at places where it's not necessary for me to look. But so far I'm enjoying it, I'm enjoying the conversations I have, I enjoy the people I talk to and, yeah, there are some really interesting insights so far.

Participant: Yeah. Oh fantastic Yeah, it's interesting how you're going to develop that into a certain direction after these interviews.

Interviewer: I try to hear insights from practitioners like yourself and see are there any ways we can conceptualise that and communicate that to a larger audience, is there any challenges specifically that is a common denominator among the people I talk to or is it, like you said, too broad of a term and we should focus on more project data.

Participant: Yeah, no, definitely, yeah. Yeah, I would be quite interested to know just in general, yeah, if other project managers believe that they do have datasets that they can use and that they believe that they are good datasets, to the point that they are applying AI to it and they're doing that successfully. I don't know if you've heard of a company called Mudano.

Interviewer: Yes, I have, Mudano, yes.

Participant: Fantastic, yeah. The chaps there are really interesting because... I quite often go to talks. I don't know if they're still based but they definitely were when their initial funding, they were based there. And that's the only real end to end solution that I've ever seen that applying AI to it did work. But they've got some really good examples of why, yes, it applies and it works but still there is issues with the data. They've got, yeah, very good case studies there. Yeah, other people have mentioned it as well, so... And I read somewhere they just got acquired by Accenture perhaps. I haven't been following them too closely because they're all in the finance industry and I'm in the construction industry so it's a bit different. But no, they did a full demonstration of RAG status reports from project management reports. They could predict what those RAG statements were going to be and therefore on a risk analysis basis predict, well, due to the experience of the project manager what kind of size of a project they should be put on, and if you put a junior project manager on a very large project, well, what is the risk of that and what does that risk look like and then trying to correlate that with costs as well, which was...

Yeah, it was pretty impressive stuff, pretty good. But then at the end they still had the problem of the granularity of data means, well, is that really utilising the full potential of the applications of AI on this or, you know, if you get someone who's a super forecaster then it doesn't even matter, you could still get a better prediction without using any of this technology.

Interviewer: Yeah, exactly, no. Yeah, sometimes my head starts to spin a little bit.

Participant: Yeah, sure. And that's where it's like going back I was like, "Okay, well maybe not looking at the application of AI to solve that whole end to end solution for the minute but the fact that, well, any one second decision that we make at the minute an AI algorithm can pretty much do a better job than us, that's where we should start, that's where it will make a massive impact right now," and that can be more powerful than the last bit which, you know, may be human intuition at this moment in time and day to day project management is still better. So that's where we see big changes right now of "I don't need to employ a massive team of admin staff to crunch the information to put it on a paper form onto a computer, I can take a photo of it and have my photo recognition AI algorithms to put that in and then do a report generated from that to tell me, well, how much through the project am I based on percentage completed of all these different forms?"

Interviewer: Have you experienced that yourself, that specifically, like that change in more automation of simple tasks?

Participant: So a lot of projects that our consultancy gets asked to come in to help with is specifically those kind of... Yeah, we go in and we've got a team who've got these management reports but for them to produce these management reports it takes a team of six or seven people a whole entire week to crunch through all the information and get it handwritten out and, you know, manual aggregations of reports in order to produce this one management report. So what we're able to do is go in instead and be like, "Okay, change this initial input from being someone's manual handwritten site diary or any kind of entry into some sort of digital form" or, if they can't change that bit, then instead of having a human being the input between the manual element into the digital element have that part of it be automated. Yeah, we often use the Office 365 platform as well and they've got Power Automate that's come out and that does have a UI automation tool built into it at the moment, so you can get that to connect to your AI models and visual models to do exactly what I've just described, yeah, have a look at a piece of paper, you know, read off all the handwritten fields.

Parts of the process for project management, I guess, yeah. So you speed up the reporting cycles. Yeah, there's a... what's it called... yeah, (inaudible 00:12:34) on the Power Automate system for Office 365 where, yeah, photos... It can pick out different fields. And this is the cool

bit as well, it does... Once you assign where those fields correlate to in some sort of data entry system of your choice, so if that project happens to be using an Oracle finance system or SAP or whatever it may be, it's quite cool how it'll pick all those up for you and type in the handwritten parts of the form and stick it into the right data entry part all automatically for you on these systems. So yeah, that does drastically change the velocity of the information flow on these projects. Certainly for me defining what a project is, just about people exchanging information, so yeah, if you get the fundamentals of allowing that to happen you're well on the way for a project being more successful.

Interviewer: Oh interesting. So, sorry, I forgot to mention in the beginning there that I think I did some (inaudible 00:13:56) on the documents to you before but I understand you're a very busy person and I just appreciate you taking this time. I do appreciate this conversation, however if I am to officially use what you share with me today I need a consent forms to be sent over. I am allowed to record it or would you like to stay out of the recording?

Participant: Yes of course, not a problem

Interviewer: Back to what you were talking about. So can you explain to me... Because I'm not very familiar with the different areas of the construction industry, can you give me the background, the basics of what Laminar Projects, what you do. If you don't want to go into detail there, if you have some confidential information, you can just talk in basic general terms as well. But can you talk me through the process how you... Who do you help and how do you help your clients? You mentioned (inaudible 00:15:18) Microsoft but for a person who doesn't have direct experience can you explain in simple terms who your clients are?

Participant: Yeah, sure. So our clients are mainly to do with contractors so they're the people who are employed to specifically build. Some of them are also employed to do design as well. The part of the process that we help to manage is the construction process mainly and the related procurement of materials and tracking of those manufacturing equipment that may need to be built to be delivered to site for construction, so... And mainly as well we're in the infrastructure side so this is, yeah, anything from our clients are building tunnels or railway stations, roads, nuclear power plants. So yeah, it's the infrastructure section so anything involved with a job as a civil engineer would do to build and it's the management of those types of projects in the construction phase. And what we would do is what's called 'project controls' which... I think that is pretty much generic to every single sector. So yeah, we'll be really helping our clients to manage the time section of the NEC contracts, NEC contracts being the standard format that is widely adopted and used in the infrastructure sector and particularly highways

and rail. And yeah, we'll go in and advise them on how to set up these systems and processes in order to manage a schedule and to protect themselves against any contract dates that they need to complete a project by and, yeah, the most efficient way for their team to tell if they're on track or not against any kind of completion date, yeah, using tools that we have to streamline the process. These tools can be anything from, yeah, Office 365 for merely just having forms and schedules that are on a cloud and online system right the way to, yeah, building them bespoke applications for frontline chaps to be filling in forms again from the coalface to, you know, utilising algorithms to help them if they are sticking to a paper-based system, how to speed the process up of getting that into a digital format. And yeah, applications to allow them to collect photographic data as well because at construction sites you can imagine it is a very visual thing day to day, more items are installed so you can see that and you can therefore see progress. So yeah, getting that type of information to be used in reports as well through, yeah, various bespoke systems that we can create on request with our clients.

Interviewer: Thank you for that. So in short terms, if I understood you correctly, you help your clients to create data within their project activities?

Participant: Yeah, and that's all for us to inform their project schedules, and the project schedules that we build for them, we make them. In the majority of cases in construction these schedules are built in Primavera P6.

Interviewer: Thank you, I can't make assumptions, and I don't take things for granted and different terminologies and so on. From your experience do you see any areas of the project lifecycle where your clients are struggling to collect the data in a digital form or can't you identify that, or have you certain areas of the lifecycle which is more a struggle or a challenge for your clients?

Participant: I think you have different problems at different times of the lifecycle. So the construction phase that we're mostly there helping them out with, that's just the velocity of information coming through, that is the biggest challenge with the data. You can set up all sorts of systems in a paper-based way and how we used to do it and that's all fine and wonderful but because of, you know, people want to know on a daily basis what's happening, weekly, monthly, and all these chopping and changing, different timelines and different timeframes, that's when getting the information into a digital format you can then, you know, chop and slice and dice however which way you want at the pace that is demanded on certainly the mega projects that I deal with. Because we could be dealing with 30 or 40 different interfaces so if I'm wanting to install a mechanical piece of equipment in one room and you've got a different trade for every single item in that room, yeah, you're quickly thinking that you're going to get 30 slightly different questions about the one programme piece of information of when are you going to install that

one piece of item, taking up how much of that room, meaning the next trade can only use what equipment or when or how. That's, yeah, when it becomes really important from our clients' perspectives that, yeah, they can get the velocity of information in and can therefore process that and distribute it back out again to be able to coordinate works.

Interviewer: If I may ask a further question on the speed of data. If I look at our spectrum of velocity on one side we have very stage-based and very gate-processed information coming in and it might be weekly, monthly or even longer than that, or on the other spectrum we have almost live streaming data. What's your thoughts on that? Have you seen actual live streaming data coming in which is used effectively or is it more somewhere in the middle there?

Participant: Yes, so if we go onto a client and we can convince them first it's setting up live video data feeds. That for us is when we get the opportunity to have streaming data we have to the second, video data on what's going on on site. That's quite effectively used. We haven't yet had the opportunity to then create streaming analytics off of that. There are companies that it might be worth having a conversation with that are doing quite interesting stuff out there. So, I mean, Microsoft have this, Google have this, Amazon have this, streaming analytics to go, "Well between this one photo and the previous photo what's the difference and therefore what is the progress?" that is quite a standard... It's becoming more of a common function that's available out of the data tool sets that are out there. And on the construction side what I've seen other people do, they would then do that using either drones as well to capture this and do that kind of analysis or, yeah, like I mentioned, this kind of CCTV or permanent camera installations you can do this on a streaming basis.

Interviewer: Actually I haven't heard that so thank you for clarifying. And this makes me think a bit more about - maybe you have come across it as well, maybe not – digital twins, is that something that you come across in your industry?

I mean, they talk about it massively and they say that they're here and they're using them but, quite frankly, I don't believe that the industry is anywhere near mature enough to really have any sort of digital twin. So in construction when they talk about digital twin it's very much at the end part of the process, the asset management part, the operations management of a live asset. Digital twin in the actual construction phase I have not yet seen being used, at least in infrastructure in this country. I think the best examples of digital twin are Singapore but you'll have to check this actually. It's one of these countries, they've actually mandated the fact that you have to have a digital twin and the digital twin needs to link up to the national digital twin and the country's digital twin.

Interviewer: Oh wow.

Participant: Yeah, it's absolutely phenomenal and it's years ahead of what the UK do.

Interviewer: That sounds like the ideal situation. And then of course if they make it compulsory then the market has to change somehow.

Participant: Yeah. I mean, it would be fantastic because… I mean, these mega projects we're on, they are doing them so they've got the capabilities that it could be turned into a digital twin but at the minute it's significantly disjointed. The dataset that I would use and require for my part of protecting the client for time and completion date doesn't bear any correlation to being able to be linked up to the VIN(?) models that are available, and the 3D models as well if you want to connect it up to having some sort of visual navigation of your project to do with construction aspects of it. So yeah, it's just strange for me that people invest so much time and effort and energy to build these kind of models and then the models aren't then able to be linked to other datasets. And quite often you get an architectural model which is separate to the structural model which is then separate to all of what's called the 'assurance information' that tells you what the material's made out of, where it was bought, how it was manufactured, what sign-off and certification went through that process. And they are all kept separately at the minute even though it is a 3D model so therefore it's come from object-orientated programming and you should be able to relate all those objects up, but nothing at the moment has had the dedication that's required to ensure that all of these different datasets are linked up and you are associating all those separate pieces of information back to the digital element.

Interviewer: Well, I suppose it's a combination of many things but is it a big like technology-wise infrastructure issue or is it a slow change process because people don't want to change because they don't realise what the benefits are?

Participant: It's definitely a cultural thing. You also have procurement issues there as well and the model that we have for setting up projects means that by default they're more naturally wanting to be disjointed and disconnected at every new link of the chain, on the supply chain that I used to deliver these projects, and that's how you end up with these kind of silo'd but in plain sight datasets really. So the structural model gets maintained and looked after by the designer, the architectural model will be looked at by the architects but because they're too different entities in the most case, yes, they'll come together at certain points along the project but they won't then be maintained as a single data source so then it becomes very difficult for that to be a source of data and trying to convert that to be a big data source that you could use to then perform any management on or allow you to do project management tasks from that.

Interviewer: I can't say I'm very knowledgeable in this area specifically but it sounds very interesting. I've been following the progress about all these technology innovations a bit by reading and talking to people like you occasionally but sometimes it's difficult for me to put it into context but interesting to hear someone like you to share your thoughts so thank you for that.

Participant. Yeah, for sure. I am interested as well myself. If specifically construction and the model for completing projects goes to more what's called 'Project 13' I don't know if you've ever heard of Project 13.

Interviewer: I haven't.

Participant: It's an initiative that was put forward and proposed by the Institute of Civil Engineers and this was to change the delivery model of construction projects to something that they're coining the word 'enterprise'. Basically, it will be to try to change the delivery model to not have such long supply chains because the delivery model would allow that there is one integrator that communicates to several different supply chains so it's then no longer a chain but everyone is kind of operating on an interface that should hopefully be one to one rather than one to another to another to another to another. And for me and like thinking like digitally, that unlocks a lot of problems because, yeah, a lot of these technologies work most efficiently when everyone is working real time in one environment. So yeah, the fastest way to get past the human problem of, you know, separating and just doing your little bit would be, yeah, bring everyone closer together, allow you to just work on one thing in one environment. That would definitely help get past... Yeah, and the digital tools are a lot better suited to be worked on in that manner.

Interviewer: I will definitely read up on that more. I'd like to ask a specific question about variety of data. Is that something that is a big problem, that data is coming in different formats? You said you had images before, can you expand on that?

Participant: I wouldn't call that a variety of data. For me variety of data is, you know, from day to day or week to week, month to month, it is a completely different data that you've decided or you require to collect in order to report on whatever it may be. For me, yeah, that's more if the format or something's coming in differently it's the same variety of data but it's the data quality that's varying. You know, the data quality can be really good on some projects and on other projects it can be really poor, and just by the fact that on a project if you've got changing teams you can have really good data quality at one point in the project that suddenly becomes very poor. On construction sites in particular, we don't actually get that much varying data in the sense that the processes and what we're doing are – especially in infrastructure – pretty much

the same. If you go on any construction site the methodology for starting works is you write a method statement, how am I going to build this, you write an inspection test plan of how I'm going to test and do some quality control on what I've installed, if it's going to do what I said it was going to do based off installing all the specified items. So that is always going to be a dataset that I can find on a construction site and that is a piece of information that, well, if I've got an ITP(?) that's signed off it means a certain percentage of the works is complete, I can use that as an indicator for progress. We've also got... At the back end of construction when you're starting to sign off everything and saying it's installed you'll always have the same process and therefore data and information that you can find about, okay, you're going into commissioning now, you've got the commissioning certificate signed off, they're always there on pretty much any infrastructure project and without fail it is the same types of data. And then we've also got... If we install something differently to what we originally designed it's called a 'non-conformance report' and that pretty much... It's even pretty much called the same thing as well on all construction sites. So then I've got a dataset that tells me when something had to change from design, so you kind of can start to use that to do the sort of change management from a dataset. And then all construction sites, when you finish you've got your snagging list and that can give you a dataset to give you an indication on quality on site. So yeah, they never change and they're always going to be there, which is good. It's not like you would sit there at the start of the project and everyone decides what data we need to collect or what kind of processes need to be there, those fundamental ones are always there. The only thing that changes from project to project is the process about how they go about doing those specific items, I guess, but essentially, yeah, they are the same; no matter how project-specific people try and tell you they are, they're pretty much always going to be the same.

Interviewer: Right. So, if I understand you correctly, you said previously that if you have different teams you might have different quality or varying data quality, however they will do the same best practices, as you've just mentioned, and... Yeah, I can't remember the terms but collecting the data in the best practice, did I understand you correctly there?

Participant: Yeah, essentially, yeah.

Interviewer: So what would you say is the reason why... As a skill among the team members then what makes the difference between having a good quality of the data and a bad quality among the skills in the team?

Participant: So it comes down to the environment that a particular team is in. If you're under pressure, you don't have enough time to record what's happened, and that record could be, yeah, site progress record, it could be just a description on the non-conformance of what was different to the original design, it just could be a poor description, it can be... What else can

affect it? Yeah, like if you've got a milestone coming up – this is quite interesting actually – quite often you will get more information coming through in terms of people will be raising a lot more non-conformances because they're installing a lot more items, so just by the nature of that they're filling in a lot more forms and then because they're filling in a lot more forms suddenly the quality of those forms reduces that data, the quality isn't as great. You get quite a rate of change of staff at different parts of the project so quite often the start of a project is really good, it's really cool, it's brand new, everyone's excited, you get quite a good core stable team, as it goes towards the end you're hitting deadlines, it's getting more stressful and people start leaving to move on to the next best thing. Knowledge gets lost on what kind of information's really important to capture, what information is actually required to capture and, yeah, things then start... they're just not getting done, essentially, and that's where you get missing data, missing information. And I guess another reason for poor quality, it could be that, yeah, the processes in order to go about these best practices, they start to evolve over time and the initial point when a process is involved in something new there's always a lull in the quality of data until the whole team gets up to speed with what the new process is.

Interviewer: Oh okay. Yeah, I really appreciate your insights. I don't want to take a lot more time, it's almost an hour that we've set aside. I try to ask at the end of the interview or conversation questions specifically about your interest and maybe insights that you would like to hear of from a research perspective. What would be an interesting area from your perspective or where you see research is not enough in an area? Do you have any thoughts and examples or areas you're interested in to research specifically?

Participant: Well yeah, I guess sort of similar to what we are trying to do is, yeah, that initial... A lot of people say, "Yeah, we've got a project, yeah, now we've got AI as well, we can apply the AI, here we go, it's going to be amazing and it's going to be great," but our consultancy – for the construction industry at least – very much believe that the data doesn't exist yet. So that would be quite an interesting piece of research to do to say, "Well, what is the tipping point in that volume of data required for AI to really become applicable in a more powerful sense rather than in getting more process automation to actually..." You know, we're getting project management to be better, to, you know, kind of evolve to something much greater than it is today.

Interviewer: Would you say that - if I might just ask a follow-up question there. In your industry the common thought is that the data's not available, is it that the data is not available or it's the data is not captured? Do you understand my question?

Participant: Yeah, no, I do. It's a little bit of both. There's many instances where where the data is just not captured. To be fair, it's probably the majority of the time the data is just not captured. So quite often you don't get the full granularity of data, you only ever get the data at

an already aggregated level, which from an AI point of view there's so much more potential when you get the very granular bits of information. Because a computer is so much more capable of handling a vast large quantity of (inaudible 00:45:13) rather than going straight from an aggregated point, and as soon as you go an aggregated point you've got a lot of assumptions in there and you've got a lot of bias built into that already so then slapping AI or an algorithm on the top of that, it doesn't become very useful or I'd question the validity on that to a point where, yeah, it would probably deter me to use that AI tool to begin with. So yeah, you're just not recording the data. And it not being accessible... So this one would come about by... Particularly in the construction industry quality is a massive part where you've got huge potential to use AI but that information you'd find a lot of contractors wouldn't want to share. Why would they want to tell people that they've done a bad job on a project, there's no problem there, their quality is really, really good, they've done a good job, that's the message that they always want to tell you. So they wouldn't want to share to you that "Oh this building had 1,000 doors, every single door we had to cut off 10 mm on the doors because they didn't fit because we had a quality issue because..." Or, you know, whatever defect that came from a particular manufacturing plant or whatever it may be, that kind of information they wouldn't want to share and it's then information that's not accessible.

Interviewer: Yeah, right. Yeah, that's a good point. So I come across sometimes these thoughts and arguments about data trusts within the construction industry. Just shortly - it's seven o'clock and we've been an hour - would you say that that is a way forward or do you see an alternative for this?

Participant: At the minute I don't see a data trust as a way forward, only because what data are you going to put into the data trust? The data needs to be there to be put into the trust in order for the trust to be useful, good. But yeah, there's going to be a point in time though when a data trust is exactly what you need but, yeah, just at the moment there's not enough data that you can stick into it.

Interviewer: I understand. Thank you for your time and thank you for your thoughts. Do you have any questions to me before we round up?

Participant: I guess not at this stage, no..

P14

Interviewer: Thank you for joining. Can you tell me about your background?

Participant: So I am in software and tech, been doing this for some time. What I found was that firstly, people don't appreciate the value of knowing the size of the software on their projects, and secondly, they do core requirements work early, but that requirement, the core requirements, but they don't realise how bad the requirements are, and the real impact of core requirements on the subsequent part of the project. So I set out to measure functional size. So functional size is a technique that's been around for a long time, since the late '70s for measuring software projects.

Interviewer: I see, interesting.

Participant: Software is the only engineering practice in the world where we fail to adopt a standard metric for sizing, a measure for size. And it's about time that problem was solved. I have found, since I learnt about it, which was halfway through my career, that knowing the functional size gives you incredible insight into how to manage, how to estimate, predict, control and derisk your project. If you know the functional size and you have some historical data to work with, you don't need artificial intelligence, you just need to apply some sensible maths and some boundaries and you can say, "Right, with some degrees off, I can tell you we are not going to finish in five months." And I did that on a project, actually, for a university. I was asked on the second or third day, you know, "Do you think we're going to do this on time, we have to do it by April, do you think we'll do it on time?" I said, "Well, based on the size it is at the moment, it's possible," I said, "But I keep going to meetings and learning about more and more scope, and I'm charting that scope and it keeps going up." And I said, "And as it goes up, the timeline will get longer, and we're getting to the point where we might miss the deadline." So a week later, I'd been to three more meetings, learned about more scope and I said, "Look, we cannot do this on time. What's more is the requirements are very defective, so we're going to end up wasting more time." And so their answer to that was – because they didn't like that answer – was to find another project manager. So I moved on to a different project for that organisation, and the project manager who took it over came to me six months later and said, "Yeah, of course, you were right, we missed the deadline, and now we're in danger of missing the second deadline, so would you give us some advice, use the metrics and tell us whether or not, you know, give us some measures and evidence, numerical evidence as to why we may or may not be able to go live in this extended deadline." And again, I used functional size and I used knowledge of the size and the tests, and some other stuff, to determine whether or not they were ready to go live, and they weren't. So size is really important. So my journey was, "Let me

invent a tool that can measure size," so I started looking at code; can we take code and measure size from there? And it turns out that's actually already been done, it's a really hard job, but somebody's already done it, well done to them.

Interviewer: Okay, interesting, so you look into scope?

Participant: Yes, scope and the requirements are key. And actually, in software, if you can be within 10 or 20% of an actual size, that's great, that's really good. Most are out by factors of, you know, 100%, 200%. So we're within about 20% of a measured size, and if you then go through the job of refining them within the tool, you can get to an accurate size. But more importantly than that, I discovered almost by accident that the process of measuring size is a really good way of looking for bugs in requirements, looking for defective requirements. And analysing the text in the way that we do exposes nine out of 10 categories of defects in requirements, partially, and is an incredibly effective way of getting a clearer understanding of scope early, reducing risk overall, and reducing rework – because about 40% of all work, coding work on Agile projects is rework, where you're retouching something you worked on two weeks ago, because the requirements have evolved a bit, you go back and rework it. Well actually, this reduces rework, because it gives you a better clarity, a better vision of what's possible before you start. It is awesome. It is awesome. The challenge is that it's a bit like a mirror, and not everybody likes to look at themselves in – or even, it's like, what do you call it, a focal mirror – not everybody likes to look at all their bumps and warts; they would rather see themselves as a movie star, you know, with a bit of Adobe Photoshop. So when you show people that their requirements are poor quality, they go, "I don't believe that, I don't want to know that. Let's just get on and code." And that's the challenge we're up against, but that will change.

Interviewer: Thanks for that. Can you expand on your thoughts of requirements and scope?

Participant: So I started to look at tech, started looking at requirements, and actually knowing the size before you start is actually more useful than knowing the size after you've delivered. Being able to measure, you know, a bridge that you built is really interesting, but being able to measure the bridge you're going to build is actually even more useful. And so I spent about a year and a half messing around, it was a bit of a hobby, and suddenly I started to make some progress. I showed it to the smartest guy I could, and it was, you know, it was starting to measure functional size reasonably correctly. And I showed it to the smartest guy I know, who's a fisherman – I don't know why he likes fishing, but he does. And I said to him – I knew if after 20 minutes he starts talking about his latest fishing trip, I knew I've got nothing. So two hours into the conversation – he's American – he goes, "we've got to show this to some folks, this is really important." And he has been a great supporter of my journey ever since. And so that's where we are. So the tool that I'd created is unique, it analyses the text of software requirements or user

stories, and it looks for…it measures the size, or estimates – I should say it estimates the size, because the difference between measure and estimate is about precision.

Interviewer: Very interesting. I've come across people who say, other people who wish in five years or 10 years, or sometime when the market is more mature, that people will trust the data, more than the opinion of a few people. Is that a challenge you see? You said, that you're trying to make people understand that the data is actually more trustworthy than their opinions? Or is it a combination – our opinion and data?

Participant: I think we're, in software, we're in a situation where the baby has been thrown out with the bathwater. The wisdom of years of accumulated knowledge of what you see, some things in software change all the time. A new language pops up every week. A new framework pops up every three days. A new methodology appears every, probably every month. And there are fundamental principles about software that just don't change, it is a human activity, it is complicated, it can be. It needs to be modularised and made less complex, made more simple, in order to be able to grow and be more profound. Most code has already been actually written, most functionality has actually already been written. Nowadays, you should just be able to plug things together to create new software. But people like to reinvent the wheel, and everybody starts on their journey with software from scratch, so they don't have the wisdom of the fact that actually, although Cobol was less sexy than Java, and probably Ruby is more sexy than Java, the fact is the principles of what those languages are doing is actually quite similar. You know, some major leaps forward have been things like object-oriented programming, development frameworks, client server, you know, browser-based technology, probably and API standardisations, those are the things that really take us a leap forward in terms of productivity, but the principles of software boil down to four things: entries, exits, reads and writes. And all software, that's what it does: entries, exits, reads and writes, and some manipulation of data as well. Manipulation is really hard to measure, whereas data movements, which is entries, exits, reads and writes, is much easier to measure.

Now, I've looked for leverage, and what we've discovered, we've analysed getting on for 100,000 user stories, and we found that on average, one user story turns into about 125 words of code. So you have this leverage of 125:1. If you make a mistake, or if you use the wrong word, or use it in the wrong way and develop some ambiguity or some confusion, you can create 125 more…125 times rework. So getting your requirements right really matters, 125 times it matters. And people will say to me, "Oh, we don't have time to spend an extra two minutes going through every one of our 500 requirements." I said, "Yeah, but you won't have time at the end of the project to fix all the problems you've created because of this."

Interviewer: I see. Can you expand of what your tools does?

Participant: And that's where they are. So in terms of AI, what our tool does, it uses natural language processing, and it uses a number of other algorithms and search techniques and other things in order to measure the size and find potential defects, and it generates tests as well, positive and negative tests. It does not, at this stage, use machine learning to a far extent. It probably will do in the future, but we're going to take quite a cautious step towards that. So all the wisdom that is baked into the tool is based on proven methodologies that I and some smarter colleagues of mine have embraced over the course of their software project management experience - and we're talking, like, well over 150 years of experience of managing software projects – to finetune what wisdom gets put into the tool. So we've chosen the best sizing methodology, we've chosen one of the most effective ways of finding missing requirements. We've looked at some of the best ways of identifying quality requirements. We've looked at some of the best…we also look for security issues as well in requirements. And we're only looking at the best techniques that we can find, and they're all based on fundamental software principles, we're not diving into the latest craze, you know. So you know, this week it's, you know, Scrum, which is a really popular way of getting a team all to work together, great. Actually, Scrum existed years ago, it just wasn't called Scrum, and now it's really crazy. There's this thing called Scaled Agile, it's a great bandwagon, lots of people are making lots of money on it, but you've got large organisations with dozens of teams assigned to work on a single piece of software, and they don't measure anything.

Interviewer: Interesting.

Participant: They will say that they do, "Oh yes, we measure story points," but story point is an arbitrary value. It's an opinion, it's the team's opinion about an arbitrary size of a piece of work. So let's say Team A says a story point is approximately four hours of that guy's work, of that guy's effort. Team B might say, "Oh no, it's eight hours of that guy's work." They can be, between teams, they can be half or double, there's no common metric between them, whereas functional size is the fundamentals – if I shoot forward here… By the way, if it helps, I'll just send you this slide deck.

Interviewer: Yeah, I would really appreciate it, thank you.

Participant: Yeah. So we presented to the US Government last summer, we showed them this slide, which was rather controversial, because they spend…there were people in the room responsible for spending billions of dollars on software, and they were using…let me just… They used the…they count lines of code. Lines of code is such a flawed way of measuring software, and unless you get your metrics right at the beginning, you can completely undermine what you're doing, from a project point of view, undermine what you're doing. So they are all doing these two things here on the left.

Interviewer: Aha I see.

Participant: They talk about how they aspire to do these two things on the right, but they're not doing it. IFPUG is a standard for measuring functional side, Cosmic is a more modern standard for measuring size. And if you measure size in software, or even estimate size in software, you can bring greater certainty. And by orders of magnitude. So you might be able to save 20% on your schedule, which is huge, because most, the most important aspect of delivering software is usually, "Can we have that scope in that time?" It doesn't really matter what the cost is, actually. They say they do, but it doesn't really matter. And with our tool and using functional size, and finding defects early, you can reduce rework.

Interviewer: Oh, okay.

Participant: Yeah, so here's the fundamental basics of measuring size and why it matters. So in software, you have an application that you're building – I mentioned before we have entries, exits, reads and writes – and it doesn't matter whether this was written in Cobol in the 1950s, or written yesterday in a combination of JavaScript, Angular, rest APIs and Ruby, you know – it's all the same. Fundamentally, nothing has changed. And this measurement methodology was invented by people with lots and lots of experience, lots of professors behind it. And it's the core of how you can deliver greater certainty to projects, and if more people adopt it, it could be the bedrock for all, I think, software analytics. So as you know, in any project, you need to manage scope, resources, schedule, quality and risks. Now, if you know the functional size, you can manage scope. If you know the functional size, you can manage resources, because you know what resources you've got, and this applies to software. You can manage all four, except for risk, basically. And even with risk, if you do good work around early requirements and you know the size, your risk will be reduced – the risk of failure, the risk of delay, the risk of poor quality, it's all reduced because you have greater visibility of it along the way, and from the beginning.

And so, yeah, so that's the theory behind it and you know, the tool's pretty easy to use, and...what else have we got here? I think many business-folk wake up when we show them this. We say.... oh yeah, we've quoted Mr Budreau(?) there.

Interviewer: Oh yeah I see.

Participant: As he's mentioned the product in his book. Yeah, so just very quickly, I'll finish off. If we're given a user story, that's the text there, software requirement, that's what the tool analyses. It works, it uses natural language processing to determine the functional steps, and a single requirement or single user story can have multiple functional steps. It detects what

objects are being manipulated and what is the functional intent. And we have a pattern matching for core date of movements, and the date of movements is the functional size. So this user story is 10 Cosmic function points, and that's approximately $10,000 worth of software. So that would, on average, would take $10,000 to develop. Now, you can have a highly productive team that could do it in half that, or a really slow, unproductive team, it would cost you more. But the US average is about...and if you know your organisation is, on average, paying $1000 a function point, then you know that's a $10,000 project, piece of work, before you start. And how useful is that? Most people go, "Oh, I'll have to the engineer," he'll say, "Yeah, I can do it in a week." It turns out it takes them four weeks to do it. Well actually, we could have told you that before you started.

Interviewer: Oh wow.

Participant: And then, yeah, so the final thing I wanted to show you, it's pretty easy to use, you can get data in and out, yeah, it's this. So for most organisations, delivering software represents a strategic or competitive activity. It's really important for them to get that delivered, ideally be at the front of the marketplace, either the market leader – if they're playing catch up, well, they have even more reason to hurry. And if they deliver it on time, their breakeven point's cool, and they can be the first onto the market and profit very well from it. If their project is delayed because they didn't manage the scope properly, or they didn't, yeah, they didn't use functional size, so they didn't use all the derisking techniques that we've been talking about, then their development will be delayed. So their costs will be increased because it's all time, it's all human, people-related. Their breakeven point will be pushed further to the right, but much more than that, is they'll be second to the market. And so, we've got leverage on top of leverage, so we've said that a mistake in a user story is 125 words, in a word of a user story, it's a 125 lines of code. There's that 125 times amplification there. If you end up building the wrong thing and then you have to go back and rebuild it, that amplifies the time that you have to spend on working on your software, and then this further amplifies the loss caused by that mistake in a user story. So it's almost triply amplified – a mistake with your requirements is triply amplified in terms of losses later. And that example I gave you about the university – they lost millions of pounds because of that, and it was avoidable.

Interviewer: Oh wow. That's very interesting to hear your talk and your thoughts. Thank you for sharing that. And I'll just...I haven't come across functional size before; is it only used in software development or can I be used elsewhere as well?

Participant: It is only used in, yeah, so functional size is for software, it's the functional size of software. You won't have come across it, because it's not widely adopted. And there are a couple of reasons for that. Firstly, the most well-known methodology, called IFPUG, is not open

source, and it's a pretty hard learn. And the people, the guardians of that standard are slaves to the original design that was created in the 1970s.

Interviewer: Okay.

Participant: A group of people who use that, the same, just like the Agile manifesto, the same, a group of people who used that standard for years said, "Do you know what, this isn't quite right, this no longer works in the modern world. It was a great idea in 1972 or '74, when it was invented, but times have moved on." And in around the late '90s, early 2000s, they said, "No, modern software architectures work this way," and so they invested Cosmic, which is a rethink, from the ground up, of how software should be measured. It's much more appropriate to Agile, and I could bore you for hours on that. It's much more appropriate to Agile, and it is the…it's not the only, but it's the best size metric that you can use on software.

Interviewer: Okay.

Participant: There isn't a better one.

Interviewer: Oh, I'll definitely look into it more, I have some questions to cover before we end. You say your tool is for requirement and scope. Can you say it is used to control the scope?

Participant: Yes, that's a way to define it. Its all about the requirements and making sure they are right from the start.

Interviewer: I appreciate your time, and I really appreciate your thoughts and insights. What happens when the tool says it will take longer than then the set plan?

Participant: Well we want to use if from the start so we don't have to go back and re-do stuff.

Interviewer: What about project escalation? Is this a topic you talk about with your clients

Participant: Interesting thought. Escalation happens all the time, we always have to deal with it. It can never go away, if that's what you mean?

Interviewer: Well yes and no. Does the user of the tool have to decide to escalate a project or no?

Participant: The tool gives them an estimate of the scope, this is usually a no brainer to follow, but not everyone want to acknowledge this. Then in becomes a problem.

Interviewer: Thank you, yeah, it's no stress for me to have it in, but I can't…I need to keep it updated in my mind, otherwise I'll keep forgetting who has done what and who I need to

remember. So yes, thank you again for taking the time, I would not be able to do my work without your effort and time set aside for this, so thank you, Colin.

Participant: Pleasure, pleasure. Okay, yeah, drop me an email with the form, and I'll send it back to you.

Interviewer: Thank you. Take care.

Participant: Alright, take care.

Interviewer: Bye.

P15 September 2020

Interviewer: Usually the conversation is 45 minutes to one hour, we have had some previous conversations before so, yeah, I assume that this conversation will be a bit smoother than previous conversations I've had where people maybe ask more questions if it's unclear and so on.

Respondent: Okay.

Interviewer: So, yeah. Do you have any questions for me before we start?

Respondent: No, no, that's all very clear.

Interviewer: Alright. So, I'd just like to ask you about shortly for the record your experience of project management and how did you end up in your role where you are today?

Respondent: Okay, so my career has been very much a bottom up career in terms of project management so I'm someone who has naturally gravitated towards organisation of outputs, systems and people through delivering projects as a civil engineer, as a designer but it was actually relatively late on in my current career cycle that I started to formalise my understanding of project management techniques and as with many things, once I started to do that it became apparent that I'd been deploying a lot of these techniques instinctively though learnt behaviour from others so that's how my interest grew in project management. Also, I found that my natural skill set and the most benefit I could bring to bear on any of the projects I was working on focused around the management of the resources and the process to deliver the project rather than the technical delivery, although I was competent in that area as well.

So, being from a technical background you tend to find there can be a shortage of people who either have the skill set or want to deploy the skill set for a project manager, there's almost a mismatch like what's the word I'm looking for or snobbery is probably the word really, you know, if you're in a firm of engineers if you want to climb the ladder you need to be an engineer, if you work in an insurance firm and you want to climb the ladder you need to be an acountant so in about 20... oh it must have been some years ago now I approached the MD of the company I was working for and explained, you know, I see myself as this glue... it was quite difficult with the timesheet system to sometimes get across how things would break down if I didn't operate in the way I was operating, you know, there was an expectation to utilise my time and that became quite a frustration to me because, you know, people weren't understanding the value I was bringing and they didn't seem to want to steer the organisation to have capability in project management they just saw it as a bolt on part of engineering which I could see wasn't working.

So, that worked its way out so I decided to move on from that position and since then I've been working freelance on and off mixing with childcare responsibilities but I've taken on it's only one large project but through that time I've been developing my project management formal expertise.

So that's a potted history of how I came in to project management really so I still see myself as an engineer but I spent time sharpening my tools, understanding the lingo, the body of knowledge, I have a row of APM booked which are, you know, some are excellent, some are not so accessible but they're generally very, very good and I've been dealing with a lot of practitioners in the projects I've been working on since, I was working in a design consultancy so, yeah, that's my route in really.

Interviewer: That's great, thank you. So, you told me that you just started on a project now for example and you said that you see yourself as an engineer.

Respondent: Mm hmm yes.

Interviewer: Would other people see you as an engineer, part of that project team or would they see you as a project manager in that sense?

Respondent: Well, that's an interesting question really and I've come to realise that there is a role that describes what I do and it's a design manager so that really is a role that encompasses project management but with technical expertise also because you have to tie together so many camps, you have to tie together the technical team, the project management team and also the client team to bridge the understanding gap between all of those groups so it's a wide role and that really probably suits me down to the ground because it does describe what I do.

Interviewer: Oh that's great, thank you for explaining. And then also can you tell me about your background or experience, perception about artificial intelligence? That is a very broad question and it depends maybe your personal background but I'm interested in your own personal background and I'm not very interested in all these technical words and you're free to answer however.

Respondent: My perception of AI. Okay, so being a process driven person, I understand the capabilities, you know, yeah, the capabilities of having good quality data to analyse and understand patterns whether it's similar as a spreadsheet or a database or beyond that I do understand the importance of data. So as part of my development you tend to naturally follow things you're interested in anyway and I've not pivoted but I've certainly followed a path along towards innovation and emerging technology, part of that exercise has taken me towards building information management and building information management really was hijacked

when it first became mainstream back in probably the end of the noughties it was hijacked and people started perceiving it to be just 3D modelling, it isn't 3D modelling it's, as I'm sure you know, it's the management of data and it's the alignment of data with the end product so the asset management, the management of an asset.

So, there's a natural drive in my industry towards the collection and management of data but also the definition of the data requirements through the delivery phase to handover to the operational maintenance phase and then to allow building owners to analyse that data. nd in gathering that data through that journey there are further opportunities which I think really your research is perhaps exploring, we have data held in common data environments now which means there's natural pools of data in a structured format that you wouldn't have had in a traditional environment so if you can't comprehend this and don't show an interest then you're going to be left behind so it's very much I am interested but also I realise the importance of showing an interest in data and what can be done with that data once you've captured it so, yeah, I have been following broadly what's going on. And to analyse this you need AI and some analysis system. Also, my wife works in retail and, you know, retail is relying hugely on data and trends from data and the analysis of and it appears to me that all industries are leading in the same direction so we are going to start learning from one another and there are things we're doing in construction that will benefit retail and vice versa so, yes, that's how my awareness of data has come, well, that's where it's come from.

Interviewer: Thank you, thank you I appreciate that. So, I will ask more specific questions about the term AI big data which can also be up to interpretation as well. From your experience have you been exposed to large amount of volume of project data in that sense that it's been useful for you or it has maybe been bad for the project that you haven't been able to manage that, what's your experience of the volume of data you've been exposed to in projects? Do you understand my question?

Respondent: Yes, I do, I do. I mean I think of it very much from a project delivery perspective of course because that's the world I inhabit so I think on the CDE, the Common Data Environment that we're using on projects I'm on currently there are I think X amount of thousand documents on there, that is a lot of data and it's not data structured into a database as such but it is data. So it's not the sort of pure structured data that would be particularly useful for machine learning or anything of that type so answering the sentiment of your question. I'm aware although I am understanding that you can ask algorithms to crawl over any data and spot trends so for example. You can use the AI for analysis.

Interviewer: So, would you say even if your role as a design manager or in the project team hasn't been exposed to the project data, you mentioned previously your organisations,

have your organisations been exposed to the big data in that sense but your role has been slightly different?

Respondent: Where I am and the particular industry I'm in, yes, at the cutting edges of the industry where they have access to data, information modelling data, yes, that's happening but where I inhabit at the moment that isn't happening, it's going to take some time to filter through.

Interviewer: Would you say that its part of the design manager's work to control the project through AI?

Respondent: Yes I'd say so, but it's not purely machine learning. I don't use much AI today, unfortunately, but I have in the past in combination with design.

Interviewer: Thank you, I might come back to that question later on. I'd like to ask the further question on the variety as well and with variety I mean different types of data and if you have been exposed to a wide range of different types of data, a variety of data in that sense that it's been manageable in that sense or if you've been exposed to varieties of data which made the projects difficult to manage or if that has been the reason why the projects have been successful perhaps, what's your thoughts there? What's the different types of variety of data?

Respondent: Well, I can come back to personal experience and actually current experience as well, the data I tend to be exposed to is often very bespoke so it isn't structured data and this is the nature of the industry and how the industry is evolving now we are pushing towards a design for manufacturing world and the project I'm on currently is actually pushing [conversation cuts off] and that is allowing a more standardised… it's driving more standardisation of construction. So data is becoming available as these projects unfold but it's a slow process and often it's only a part of the supply chain that's engaged. You basically have an architect with an information model and they're having to manipulate data into that model so they're very limited in what they can do so there are big question marks about interoperability of software tend to be forced onto one ecosystem which some parties don't have and that's all evolving to it. It's quite an interesting evolution where it's very much akin to Microsoft versus Google so we're in a Microsoft world at the moment where they try to corner industry with their technology and software and there were some disruptors and that disruption is happening now. So the equivalence in construction are Autodesk and the large software suppliers and that's interrupted(?) by some smaller suppliers with the help of UK BIM Alliance.

Interviewer: Velocity which is the speed of data and if you've been exposed to a high velocity rate if that's you can say data in projects in that sense that you've been maybe exposed to data in a very updated manner, in a very maybe even live stream data

sometimes or if it's been more manageable and you've been gathering data in very stage process manner or if it's, yeah, those two spectrums there, what's your experience there?

Respondent: Again, just the nature of the industry we're not at that level of maturity yet where we can capture data in that way yet, it's coming but we're not there yet. At the other end of the spectrum in the asset side of things, you know, that is happening very much so, so where I am, no, I'm not being exposed to vast quantities of data although I know that that is coming. The challenge in construction is we build in a physical world unlike many other industries, banking or retail, you know, they can pretty much they've got a blank canvas within reason so they can create their own virtual world and catch data as they wish, we're constrained by the physical world but having said that, there are many opportunities to systemise, modularise and use modelling to lever not only what can be generic but also to capture data from previous projects to understand how many documents we're likely to produce. Different tools are used. You could dashboard look at those sorts of curves to understand the frequency of update and when models may be ready for construction and to see whether you're on target based on previous experience of data.

Interviewer: And you mention BIM a lot and we've had a discussion before about digital twins I believe as well.

Respondent: That's right, yeah.

Interviewer: I haven't had the opportunity to read up as much as I maybe wanted to within digital twins and we might have discussed this previously but because this is now when I collect data I might repeat myself from previous conversations, what about digital twins in the construction industry?

Respondent: Okay but that's interesting because since we spoke I've spoken to... obviously spoken to a number of people in the industry and some people who've inhabited this world for a while and I spoke to I think he was the sales director for a building management system, and he pointed out to me that actually digital twins are a new name for BIM and it means the same thing, it was the original concept for BIM but BIM hijacked because people started to refer to BIM as 3D modelling so now we've had to introduce a new term for BIM so originally BIM was meant to be digital twin.

Interviewer: Yeah, okay. Yeah, it makes a lot of sense when you tell me this I mean I haven't been able to distinct them both and it depends maybe to whom you talk to how mature the organisation you talk to is.

Respondent: Yes

Interviewer: Okay, I've come across through you as well there, I can't remember but, yeah, the principle or similar to that that they refer to with the digital twins and I might, well, I assume that I might include that as a chapter in this report just as a background but because I'm cross industry with this research I'm not sure how much I should focus on specific industry pieces but, yeah, it's nice to hear with your own words someone who has experienced by themselves.

Respondent: And I haven't heard that said before, I think that was quite an insightful comment and as soon as he said it to me I thought do you know, you're right, that's exactly what's going on here so, yeah. But interestingly though, once digital twinning... BIM is going to drive digital twinning of course, it's the backbone really to... it's one of the backbones there are a number of backbones, it's one of the backbones towards that and it's going to result in an enormous amount of data capture. I think that will start to back feed into the construction industry though because of course when we start to understand operational data more we can start to adjust what we're doing to serve that because there are going to be things highlighted that we hadn't considered so we're enabling it in the first place hopefully and it will then hopefully back feed to us so employers information requirements will come back having taken that into account. When we have less relevant project data, when we sit in meetings, people tend to question the AI model's outcome more [trust in AI model] [willingness to take corrective action].

Interviewer: Thank you, that's great, very interesting to hear. I don't have any specific questions more about the data, I'd like to ask you maybe a more specific question about your current role as a design manager you said.

Respondent: Yeah.

Interviewer: I read a text... Right now I'm learning how to build a social, well, it doesn't matter but with my PhD I'm learning some social science models and designing the models they say is more important than actually executing the models because if the model is wrong you will do it wrong.

Respondent: Correct, correct, yeah.

Interviewer: And, yeah, I'm quite interested to hear about your role as a design manager, are you able to explain what you do more specific as a person who doesn't have any own practical experience in your area?

Respondent: Yeah, certainly. Now it is a role that the first thing you have to be is adaptable so you very much have to follow the culture of an organisation, how they operate and how the staff operate so a design manager has to like people, they have to be able to communicate well with people and essentially be the glue between all of the moving parts in a project, the technical and commercial and delivery parts of the project. And also the project manager's role is different at different stages of the project so, you know, in section stage you're dealing with sort of more front loaded with documentation and initiation, you know, getting things off on the right footing, kicking off some feasibility studies maybe and supporting that work, identifying risks. And then as you move into design you are coordinating design teams, managing the delivery of documentation, ensuring that it ties up with, you know, what you've essentially defined as a requirement, as a series of products, outcomes and deliverables and you are responsible for managing an integrated programme between the designers as well as chairing design team meetings to ensure that there aren't any gaps so there's a lot of responsibility metrices in terms of roles and outputs. The sooner the quality team and I find tasks that are not up to standard [rework discovery] we can improve the project, and it we can learn from our mistakes. When we have delays, more data is generated [project data generation]. It can be seen as a win-win to improve.

So, at the moment actually I'm just starting a, well, I've been brought in for this particular work package on this project I'm on now and I'm working for a project manager but he's from a contracting background and for a couple of days I've been trying to persuade him the importance of a product breakdown schedule, I do it in spreadsheet format but it's an all encompassing product breakdown schedule but it not only defines the products but it defines the products how they're grouped. As I've explained briefly this is very much an area breakdown structure because it's a linear asset we're building and there are many different areas, there are local authorities, there are landowners, there's ways that we group to the Environment Agency to get certain approvals so there are probably 100 different ways that the route can be broken down so it's imperative you understand how you are looking at these deliverables in terms of how they're broken down on a spatial basis. And then against each deliverable I've got a series of columns which are it's essentially a RACI so by the manager, particular managers we've got, environmental manager, project manager, design manager, project engineer, all of these roles and then the suppliers in the work package, you know, whether they are responsible, accountable, consulted, informed and then beyond that when each of these documents needs to be issued and at what status, so I've got I think it's something like 12 stages because they've got various gateways to go through and I'm putting in the code for the particular status of that document at each stage so a document may be issued three times with three different statuses and then I've got a column that says when that document first appears so you can sort by who's

responsible for it and you can then sort by when that document first needs producing so you can say here's your deliverable list and your outcome list so it's more than just deliverables, it's outcomes as well, very much along the lines of APM conceptive products. And they then can manage, you know, we can get that tied in to subcontractor packages and all the stakeholders can comment on that as well and we can have a consensus about what's been produced and who's producing it and when. And that goes two ways then, that goes up to the programmes so I can say to the project manager here are your milestones, go and work out how they all fit together and I can help you a bit with dependencies but they're basically your milestones, go and make what you will of it.

Interviewer: Well, that's great. I'd like to ask you a follow up question and maybe I misinterpreted the use of the word linear as you used it.

Respondent: Linear, yeah.

Interviewer: But overall you can still call yourself project manager in some context?

Respondent: Yes to some I am a project manager.

Interviewer: Linear, yeah. On a side note I use the complexity theory within my PhD which is a fancy word for just a non-linear systems and social systems as in project management perhaps and the discussion I'm reading and talking to people, well, mostly reading literature, I'm trying to build a sense is a new type of signs that is accepting that we're not living in a like linear world and everything is too complex that we can't force it within a linear environment. How does the construction industry manage that when I'm not sure if you use the linear in the same way as I use it now but how do you deal with complexity and complex with like the managing a complex projects in that sense?

Respondent: Yeah, no, I know exactly where you're coming from, now I'm going to introduce some pop psychology here because you're the brain here in the academic world and I've read around but maybe in a more popular environment so in the last year or so I've digested Stephen Covey's 7 Habits which I really like, an effectively really good back. In my past I've read Getting Things Done GTD, you're probably familiar with that, have you heard of Getting Things Done, GTD?

Interviewer: Eh I don't think so, maybe, I'm not sure.

Respondent: A couple of bits that are a little bit too far right for me but the majority of I got ironically having his own battles at the moment now I believe so through all that I've realised especially Jordan Peterson said chimes with me and his mantra is that chaos introduces conflict, okay so we have essentially a society where we have spoken and unspoken rules that

we adhere to to allow us to know where we stand with one another to avoid conflict and I see my role and the industry I'm in as very much having to satisfy that mantra. We have to have things we can centre around and in my formalisation of my knowledge around project management I found something I can centre around, give a name to and other people understand what I'm talking about so when I say product to you I assume you understand I'm not just talking about deliverables but I'm talking about outcomes as well. And I totally agree with your sentiment that the world is not linear, we have to find out ways to harness and manage that but we do need common language and it goes back to systems design in my industry as well as interoperability and process, when are we too constrained? Others are very clear, you shouldn't introduce process unless absolutely necessary, you should give people agile ways of working are introducing this as well to allow development teams to have that creativity but I will argue that they still sit within a wider framework of common language, they just happen to be in a small world although they often think they are the world, they actually sit within a small world where we de-constrain them to allow them to be creative.

So I think that's the way societies have always been and I believe that we can harness I'm sure, you know, broader thinking about, you know, we don't just have to always be ordered but we have to have ways we can do business with each other and [cuts off] one another and we have to have a language whether that's formal or informal, that's my belief anyway and that's digesting everything that I know and have listened to people and no one person seems to have an answer but that's my interpretation.

Respondent: Just observation really, it's quite interesting because you're clearly… am I right in saying you see yourself more as a social scientist?

Interviewer: I mean social science faculty but, yeah, and I'm doing within business and management so yes.

Interviewer: Okay, so I have a few more questions I need to cover. What about when you used AI, did you use it for escalation and control?

Participant: I guess you could say so, it's not that straight forward perhaps, we use it as a tool and it assists us.

Session 2 September 2021

Interviewer: Since last time we spoke I have made come modelling of causal loops. I would like to iteratively collect data and adjust them with you base on my data analysis.

Participant: Interesting. Go for it.

Interviewer: I'll share my screen with you here. Is this an accurate visualisation of what we talked about? You can follow the different polarities and the effects with the name of the variables.

Participant: Yeah yeah yeah. Some terms I may not be familiar with but in the context, I understand them.

Session 3 January 2022

Discussing the causal loop over the phone, no recording of transcript available.

P16 February 2021

Participant: Where I'm interested in is that to use simple planning heuristic, and gift it in the hands of people on the floor, that they can decide what to do, based on heuristics. And so I'm very interested in local knowledge, which local knowledge o the people on the floor, which I can't put in the algorithms. This is also the first direction towards AI.

Interviewer: Yes can you expand on this please?

Participant: And this is my objective for that, that I have to design an experiment, do the experiment, and analyse the results. And this is a screenshot of our system that you will have seen at our website. But on top of it, you see the projects, below you see the resource load, that will always be right in place, and if I have this, that the resources are quite balanced, and I have the projects, as I know the objectives of the projects, then I can derive from this task lists. So based on this, after each line here is a project, there is an MS Project plan or a Gantt chart, or whatever, what I use. But from that, I derive, based on PR heuristics, I derive the priority list. And now the…so this is for the group construction, they see this list, and red means they are actually already too late, yellow is requires urgent attention, but you just have to execute the one which is on top of the list, or give a good reason to deviate from it. And I'm very interested in those reasons, because the things, the outcome of the experiment will be, wait, I expect it a lower…oh, I will come to that later. But this is then, this is everything I am interested in. And I'm particularly interested in those reasons and I will come back to that later, I will show you some examples of that. Why do I think this will work? And I will come back to this later, in relation to AI, because this is based on the model of XX (inaudible), and this is quite interesting that it's redone this experiment, what is researched in 2004. And I give them more job autonomy, yeah, by giving them the resource lists, "It's not the manager who decides, you have to decide, based on this list. "And I give you more perceived control of time," okay, this is what they think they have, yeah, because they are in charge. Because of that, you will see that stress will go down, job satisfaction will go up, and the job performance will also go up, this is…although the theory will tell us this. And I take into account in that I take the workload and the planning I will not change it during the experiment. And so the outcome of the result is that people will follow the priority, or they will deviate from it. But now, it can be that they have a non-justifiable deviation from this list, yeah? Or a justifiable reason. And here is the trick; how to judge if it is justifiable or non-justifiable – I can't, but I let the team decide.

Interviewer: Okay interesting, can you say this is part of project control as well?

Participant: So I asked every time in the team, "I hear you deviate from this list; why?" and they give a reason, and I ask the team, "This is a good reason – yes or no?" This is, in a nutshell, what

I did. And I did this for half a year, I ended it – you don't see December here, but it's also there, it went even…the green line went a bit more up. So green is that they followed the priorities. At the beginning, when I started, it was a drama.

Interviewer: Yeah, I understand. Is this a RAG system?

Participant: It was really a drama. But we took actions to get rid of the red part, but the interesting part here is that also although we improved the planning, the yellow part is about the same. And because – and this is quite interesting, because apparently, we could not automate this. We could not get away from the yellow parts. And if you look at the red part, the reasons – this is just a word-cloud, and I classified it, and the big letters have the highest amount of reasons in that class. The highest amount was, "I can't resist to help others." Somebody is coming to your desk, and you want to help him. But if you look here, that the red regions, that went away. In the end, more and more people got convinced, the management was also actively using this list during their meetings, so they could not ignore it anymore. There was no reason to, they were already brainwashed by it. So this is in a nutshell. But now the yellow part, and the green part – and the green part is the highest, they just refer to the highest priority task, it was just the major one, yeah? But now the other ones – and there you see all kinds of reasons, which I find very difficult to incorporate in my algorithms. In my non-AI algorithms, yeah, in my PR heuristics. So this is quite interesting, but maybe with AI we can improve this. I don't…I will come to that later.

Interviewer: Yeah. What happens when the project escalate?

Participant: If I could use the local knowledge of people to improve the resource allocation, which was all…this red grid, you use the local knowledge, yeah? Now if you can compare the human brain via the heuristics, then yeah, for the heuristics, I only take into account workflow, deadlines, team capacity and skills, the only thing, simple heuristics. And in that case, the heuristics were very helpful to prioritise, it really improved the way how they looked at their assignments, it really was a big help. But in this yellow area, there were much more other parameters which I did not take into account. And in that respect, humans were much better in taking the criteria decisions, which is also a conclusion which is already made in the end of the last century. But humans have a limited connective space, they can only look at a few items. Now, the heuristics helps with that, because they only look at the top of the list. I'm not worried about, say, if they only decide within the top 10 items, which is already good, yeah? And they are able to adjust within this top list, and also the theory of anchoring and adjustment, because we provide focus. Your brain only looks to this part, naturally, and they will decide. if this list is of a good enough quality, they will decide what to do, this is the principle of anchoring and adjustment, yes? It makes sense?

Interviewer: I think so, if I ask about your background, what is your experience in AI?

Participant: Okay. And this is already in 1974, yeah? But now the effect of AI and you will also see where the, you know, also the dilemma I have internally, you will then also see. Suppose I replace this planning heuristics with AI learning, and we are now on the track to do this. I still have this local knowledge at the other side, and this cloud. What is then the effect can AI learn from those reasons why I deviate, and adapt their algorithms? To some extent, I really think, because AI is much better in taking multiple objectives into account and to find a kind of optimum then. So I think it's fair to say that AI is better capable in handing multi-criteria decisions than heuristics are, and this is already proven. See, I don't have a good reference for that, so if you could help me with that, that would be nice.

Interviewer: I see okay.

Participant: I think you have, because you have more knowledge about this than I have. It would be nice if I put a reference here, although it's not part of my study. It's just my interest area. But what happens now is AI becomes the norm, and I exaggerate a bit here. For now, what I tell to them, deliberately, that this list is not perfect, what I give them. So they have to use their brain, but if I put good AI algorithms in to make this list better and better and better, it will be harder to deviate from this list. That's just a cause and effect. Because you're really, yeah, you set a high norm for this list. So probably the job autonomy, the better the list gets, the longer the job autonomy is, because you just have to follow this list in the end. And the feeling of perceived control of time can go down, which is, if I just follow this model, this is the effect. But there is a but – it's not all negative – and this is why I have the dilemma of course, because AI systems find a much better way to balance workflow, workload and capacity, if I improve this – better planning behaviour, better workload distribution. So this is the dilemma that I have, and from that side, it will improve. And for this job autonomy actually, I have to put the question mark there; I don't know. I don't know how it will affect people in their behaviour, because there is…for me, there is no reference, what it does with the people. Yeah?

Interviewer: Yeah, can you expand on managers' view of AI?

Participant: And although the people, if you are unknown to something, they are scared. So if they are unknown to AI, people are already scared of some things that are coming. Some people embrace it, some people are scared. But it this…then I showed that if they want to look more. I didn't do this on purpose, we didn't plan it that I showed this, because I like this, it's very down to earth. I will tell you something about what I'm already doing.

Interviewer: Yeah. That's great, thank you, thank you for sharing that. It did answer some of my questions. I do have a few questions also about maybe you mentioned that people are

scared about AI? And what are they scared about then? I'm trying to also look into how the data management can be improved in order to actually utilise AI to start with, so if...

Participant: Yeah.

Interviewer: May I ask some questions about your experience in that area as well? If you mention anything that is confidential, it will be treated like that as well. So may I just ask broadly why do you think projects fail at such a high rate today?

Participant: Because it's just...they just put too much work in for scarce resources and whatever algorithm you do, you will not make it, you don't need any algorithm.

Interviewer: Okay. So you mentioned it before, but just quickly on my specific question, how do you think AI can impact project management?

Participant: Yeah, that's, indeed, a very broad question, eh? Because why I'm hesitating now in giving the answer, because to some extent, algorithms can already do, but some, in a multiproject environment, to make multi-criteria decisions, there it can help. And that's something I cannot fix with algorithms, it's too complex, because it's too complex for managers to do, to help them to fix multicriteria decisions.

Interviewer: Yeah. So it might go into my next questions, which is considering other professions, such as health and medical professions maybe, also law and where they screen a lot of natural open texts, they can see impact by AI, but project haven't really. And you mentioned previously that we can't grasp the multiproject environment – do you find any more specific areas why AI hasn't come into project management yet?

Participant: That's different...yeah, that's a different question, why it hasn't, because compared also to production environments, project environments don't have structured data. If you look at medicine, for example, the healthcare, they have loads of structured data, all the photos you make are structured data, you can learn and you can improve and you can add expert knowledge to it, but if there is no standards – there are actually no real standards in project management, then it becomes very hard to learn.

Interviewer: Yeah. No, I understand that, definitely.

Participant: In AI, it becomes hard to learn.

Interviewer: Okay, so going into that specific area then, do you see anywhere in project management where there is structured data for us to use? Maybe in specific phases of the lifecycle? Or in your own experience?

Participant: If I see where, if I see which type of projects we do, and if I come to a company where they do repetitive projects, there I can learn something, because I know, okay, the next time this project is more or less the same, and I can compare to the one before. There it becomes useful. And actually, this is also where I'm always writing to, that first I want to develop templates with the customer, make your project templates. In our product, we have a module library that they can define modules, maybe the project it differs, but the modules are the same. If I do the first phase, we always do it like this, so that I can compare, I can put descriptions on it, I can put text in it, I can put baselines on it, and then I can compare. So there it will be…then I can learn.

Interviewer: If I may ask a specific question for that, so if you create your templates, and you can compare them through your templates, even from different projects, can your product compare that itself and suggest an AI algorithm suggestion, or does the project manager itself still have to do the comparison between the different projects?

Participant: We got a subsidy of the…do you call it subsidy? Money from the government…We got subsidised to investigate AI. For last year our objective was to structure our data, to put different data elements in it, that for this year, we hope to get our proof of concept for AI. But we have to find those questions – where do we want to put our money on, yeah, to start with. So this is the first thing. Now, maybe you have to rephrase your question, knowing this. Because in my opinion, nobody in the world has AI for project management. If I spoke to my partner, because we got a request from a big company in the UK, and they wanted to have AI in project management, and IBM was hosting it to find the right appropriate partner for it. It's a huge company, they are in the defence industry, so they really know what AI is. So they know what AI is. And a long story short, we are the one who are now…they chose us to help them with multiproject management, with the statement of that nobody in the world really has an AI solution for project management. There are some tiny bits that people do and the structured data is, I'd say that it was 80% of the job done. Basically it's way more than 80% of the job done.

Interviewer: That's an interesting perspective, because I hear people saying that, yeah, most of the people who do have a solution like you to offer, they don't…well sometimes they might sell it as AI, but when they actually discuss it, they know there is a quite far from real AI, as defined.

Participant: Depending on how you define it, of course. I want to show you something. Which just happend this morning happened – and I was furious about it. This does tell you how I look at the people who are misusing AI. And you can see my screen now, eh?

Interviewer: Yes.

Participant: Then I go to a chat with my marketing manager, you are not going to put his name in the conversation, and you are not allowed to mention this name, because this is the name of this customer.

Interviewer: Of course.

Participant: "Hi X, these statements bring me big problems," and this is about this screen. I saw this happening in Facebook this morning. "smarter project management with AI-powered task prioritisation." So I was now blaming my marketing manager that he put such a statement there. And then you see, as I say, I said, "This will bring me big problems," and then I said, "Oh, but you got me a little bit worried here. We never run an ad like this." What happens is that Facebook is generating, suggesting such messages on their own.

Interviewer: Aha, I see

Participant: There is an AI algorithm of Facebook which knows I'm interested in AI, and so this is sponsored, but it's not, okay, it says, "Only you can see this preview." It's not that I...I was afraid that we put this message out to the world already.

Interviewer: Okay, yeah.

Participant: That this is then you also see how I stand really in it, that I don't want to promise something

Interviewer: No, it's a very interesting idea, because I tried to talk to practitioners like yourself. Some people are very far into the, if you call it AI maturity, mature within that area, where they know different terminologies and so on. Other people are still exploring it, and there is a...I've found quite a, well, differentiating, where people are very free to, well, feel that they can use AI very freely if they have low maturity of AI, if they are quite early on. If they are very technical-oriented, they are very careful with using AI.

Participant: Yeah. If you are a PhD, you learn that if you say something, you have to prove it.

Interviewer: Exactly, yes. Yeah, so when people talk about AI to me, you get very sceptical to begin with, but again, it's a very undefined, well, difficult to define, I mean, 20 years ago, AI was something else, and 50 years ago, AI was something else.

Participant: Yeah, and I now dare to say that if I compare it with other companies here, we will do all those claims, and we also discuss this with IBM, they said, "Yeah, but it's quite fair that you say you are quite far in... It's not really predictive analytics, but you are more close to it than many of the other companies we have seen." And so that term, I told my marketing, it is something you can use, because we have all the data, we make all the graphs, we can predict

why this milestone is red and this one is yellow. This is what we can do. And maybe to the exact letter there can be a debate, an academic debate about it, but for the market, I told them, "You are not allowed to use something like predictive analytics."

Interviewer: Okay interesting.

Participant: So this is where then you also know where I stand.

Interviewer: That's good, thank you for clarifying. May I just ask there, because yeah, I do hear people coming across that they'd prefer to frame it as predictive analytics; how about prescriptive analytics, do you have any thoughts there? Would that be a next step which is more AI? Or can you explain that for me, if it's possible?

Participant: With prescriptive, you mean that I suggest to people what to do?

Interviewer: Yes, I believe so. In my…I've come across first descriptive analytics, very simple, and then predictive analytics, which you just described, and then people come across quite carefully trying…using prescriptive, but that's many people's goals, at least, to be able to create the prescriptive analytics. Yes, but with…actually, you could say that the task list is a kind of prescriptive analytic.

Participant: You could say that. But it's just a heuristic. So prescriptive analytics is, for me, more in the area of AI. I see, however, that this is coming back to your question you put in the guidelines you sent me, "I wonder which areas do you see?" this is a huge area of interest here. Because if I want…I talk normally in pictures, so if I have the task list here, and I have to add – it's a bit slow, because we are also on Skype and I'm not at a site which has a very good Wi-Fi access.

Interviewer: That's okay.

Participant: But it'll come. Yeah. So here, if I have to assign somebody to this task, this would be for my…a huge benefit, if I could use AI here to say, "Add resource to this task," now I have to select somebody, who is it? Yeah, I know the first, I have to pick from this list, but if AI could help here. And we already…the assignment of skills – the direction we want to go in is that beside the parameters you just saw – and this is just a design, that I put in this task, which skills are required. This is still not AI, but here is where AI can help. This is what the task requires from skills, a lot of (inaudible) are split, a little bit of this one, yeah, this is the level of skill I require.

Interviewer: Oh, cool.

Participant: And then it suggests, "Ah, you have to pick (inaudible 00:32:11), because see, this is green and that is green." This is what we can already do with the algorithms, but here AI could

help – in both directions, it should help me, but I think this is really the next stage that it could help me to define which skills are required for this task, because this is already quite a job. And the next thing is how good is (inaudible 00:32:36) in doing JavaScript. So what I will add in the coming months, is to implement this, that I have those parameters in place, and then find a way, how can I use AI to help me to suggest it. And this is for you, what you call this prescriptive analytics, correct?

Interviewer: Yes. I believe so, yes. So what happens when it goes to yellow or red, what happens during this escalation?

Participant: Now so this is an example, and besides skill, I also want to know if they have capacity in that period of time, this is the battery.

Interviewer: I understand, okay. So yeah, I understand you add features piece by piece when you do updates in your product, have I understood that correctly?

Participant: Yes, but all in mind, how can I use this later to optimise this by using AI.

Interviewer: That's very interesting. Thank you for sharing, yes. That's a good example there. So I might have a more binary question for you, in seeing how you, yeah, what's your preference when using terms for data and data. My perception is that project managers are a bit careful with…strange to using big data term, which is completely understandable, but I would like to ask you, do you have any experience from big data within projects? And big data, I refer to the three Vs, volume, velocity and variety.

Participant: Yeah, but the question is what do you define as big?

Interviewer: Yes.

Participant: And the problem here is, I start in the beginning telling you that it is, I can only learn if I can compare something. So what is big data for project management is a very difficult question to answer, because can I use data from one company in another to learn? Because even within a company, it is difficult to compare from one department to another, because they're doing really different projects. And besides the question, if it is allowed to do, but maybe we can find a way around it, to remove all kinds of…to put everything as ID, only user IDs and…I'm not interested in task names, I can use only the figures, and how it works. So maybe there you can get away with it, but then it is how can I compare it? So back to your question, that you said it was very binary and now I have made it not binary – I don't know. It's very difficult. I'm thinking about it, but I think it has to come from the company itself, yeah, we store everything. Yes, we store all data, and we also export it, but can load it in Power BI or QlikView, or that kind of thing. We make it all available to work with, yes, in that respect yes. But really big, so the

definition of big, to use it over different companies, I think this is for the whole world, a new area to explore.

Interviewer: Thank you for sharing that. Would you, so if I introduce a complex project data instead, so I could ask you if you can choose between big data, complex project data, or simply project data, which one would you be most comfortable using when you have conversations with your team and with your clients? Or if any of them?

Participant: Yeah, I don't know, with simple project data, you could say due date performance, and maybe some overall statements. This is…I am not so interested in that actually. I think this is, yeah, that you could gather in large amount of all your…even over different customers, but that's not the interesting part. Again, I think it will be the complex part – why are you deviating from this task? Why is this happening? Why…can I use this data to tell why is the right man for this job. How can I predict here…wait, where was my…I have different sites, oh here I have to be, yes? We were looking at another site. This is my old site.

Interviewer: Okay, it looks nice.

Participant: We also use our own product, of course, to develop the algorithms we sell, we also use our own products.

Interviewer: Oh that's great, that's really good, then you get real insights as well.

Participant: Yeah. This is the best reinforcement learning you can… So I want to be able, if I have here my projects, and this is what I already call complex, I want to predict if this milestone is feasible, yes or no. And why is this not feasible between that, and what do I have to do to prevent it? Are we already quite far with it? And so here is where…so in retrospect, fi you call this complex data, I am interested in this complex data, not the simple ones, I leave that to the others.

Interviewer: Yeah, no, I understand, thank you. I'm seeing the time now; I think we set aside 45 minutes in our correspondence before. I think we started at 20 past, yeah, 50 minutes ago. If you have 10 minutes more, that's…

Participant: Yeah, it's no problem.

Interviewer: Thank you, much appreciated. Let's see, yes, so we've covered that. From my own reading from your product, I understand, you mention on your website that you use critical chain project management. So it's based on the Theory of Constraints, I believe?

Participant: Yeah, yes. So that's, yeah, ask your question please?

Interviewer: I was just going to ask an open question there. What's the thought process behind that, and because I've come across it before, but people might also mix up a bit critical path method and critical chain project management. Why would you choose critical chain project management instead of critical path, method, for example?

Participant: Yeah, actually, the question to be asked should be how do you apply theory of constraint thinking, because critical path or critical chain, in a multiproject environment, that's not, yeah, that doesn't matter that much.

Interviewer: Okay.

Participant: That's not really…but you should focus on the constraint, and that's what you see here. If you see the projects here, for example, the top one is the one who is the most in danger. And yes, if I open it, you can see the path, and I can focus on, "Show me only the red items here," and I only want to see…expand all. So this is (inaudible 00:41:47) so now, in this mode, this is still a critical path, no sorry, this is the critical chain. I will show you the critical path, I have both, yeah?

Interviewer: Okay.

Participant: This is the critical path to this milestone, so everybody knows, "I have to focus on this to be in time." And I don't use those terms, I only say to them, "This is the most important thing to do," I don't use those terms. So this is regarding projects. But if I look here, so the management attention goes to the one who is in the most in danger, this milestone. Here, if I look at the resource logs of all the projects, I do the same. This has nothing to do with critical chain or critical path, because I told you the most important thing is that I'm not overloading resources. There is the constraint. So here I see, "Hey, you are overloaded here," and if I compare it to this, "You are underloaded." It'll be above the zero line you are overloaded, below the zero line, you are underloaded. And if I take this project in, this is in active projects, I want to analyse the effect of putting new projects in. You see, "Oh, then I am overloaded over here." So it's all about constraints. And where do I have to focus on? I have to focus on this resource group, because this is my constraint, yeah?

Interviewer: Yes I see.

Participant: But it goes further, because this on macro level, that's why I say the ToC way of thinking, constraints thinking, I don't want to call it ToC, because I get in problem with the…it is ToC-related, but it's really constraints thinking. If you look here, then I want to zoom in from the macro to the micro, I call this. So here, if I'm at a meeting, on the spot I want to have real-time data, "Show me why is this project in danger." This project is in danger because this task is

generating…is my constraint. So from project constraint, I go to task constraint. So the objective of the organisation is now drilled down to one single task, and here I see, "Okay, yeah, as far as I can see, this is ready, so if I mark this task now as completed," – and this is another aspect of it, if I say, "Hey, this task, I complete, then…" and this is the really, again, the Theory of Constraint thinking, the five focusing steps, this issue is fixed. So if I go back to my pipeline, project three was in red, then you start all over again. Where is my constraint? And this is how I implemented the five focusing steps. Yes?

Interviewer: Yes, okay.

Participant: It is not exactly the question you…the answer to the question you asked, but this is a bit of a higher level, for multiprojects, you have to look at a higher level.

Interviewer: Yes, no, it's very good. I want to have your words and your perspective on this, so I appreciate your answers there, thank you. Yeah, because I'm exploring a few theories to include in my own PhD and I've come across complexity theory, and project scheduling problem, and…do you have any experience there? Any insights there?

Participant: Yes, my… my other partner, is using the complexity theory for his PhD. But he's more related, because actually, this is all quite straightforward for this here, but the real complexity is the change process behind it. This is real complexity theory. And then you have emerging behaviours, and that kind of thing, but everything here is designed to drive the change. It's not…you saw that in my presentation, we are not forcing a change, we want people to have freedom, but there are some cognitive tricks in here, like anchoring and adjustment, to drive them towards resolving constraints.

Interviewer: Of course. Well that makes sense.

Participant: The other theory that is behind it is system thinking.

Interviewer: Yes. I'm adopting as well, system dynamics, which is within the system thinking.

Participant: Yeah.

Interviewer: And it's part of my PhD to, well, to use system dynamics in order to, well, I'm very early still, I'm in my sixth month of my PhD, but my later stages, I aim to use system dynamics in order to measure or compare algorithms, if I use that term. But yeah, that's a bit far ahead still, but I'm exploring the different areas. So it's interesting that you mentioned them of…

Participant: Yeah, because system thinking, to let the system run, you need guidelines, yeah, objectives, where the system is going to, and this objective must be non-conflicting with other objectives. That's why I use simple PR heuristics, because then I don't have conflicting objectives. Another thing of the system is you need a buffer – systems will not work without a buffer, because there is uncertainty. So everything you see here, if there is red, I don't have room for uncertainty. If I have yellow, then I have some room for uncertainty here. Green, I have a good room for uncertainty. Blue means I have actually too much space for…the lead times are too long. So this is where systems thinking comes in, and it goes also back to if I perform here, I also have to look back to the past, to see what I plan here against this zero line, if I can really make this, because if my performance, if I cannot deliver to this performance that I expect, this whole plan is bullshit. And this is what you see here, and this is my main KPI, this is the historical log-graph. And this is fake data, but yesterday I discussed this with my…with a customer, those kinds of graphs, and you see here the capacity that they have, this blue line, historically, yeah?

Interviewer: Yes.

Participant: So we looked in the past. And this is the output that they delivered. The output means if you have…if I give you four tasks of 10 hours in a week, and you delivered only one, well, either while you spent 40 hours of work on it, your output is only a quarter.

Interviewer: What about your product for project control and planning?

Participant: Your plan output, because – and that's important, because if I plan against this, actually, I plan against this blue line in the future, then I should also deliver this output, otherwise I have a huge problem. And I don't want to put as a KPI 'efficiency', because then they deliver always according to this blue line, but they don't deliver according to the priorities. So if I see red tasks in the task list, I expect to see red output here. If you mark something as completed in your task list, it appears as red output here. If I see only blue output here, and I see that I have projects in danger for this group, for assembly, then I know you are messing up with the KPIs.

Interviewer: Yeah okay, so, yeah, I see that. So from the left on the screen, you have more yellow, and the time goes by and they turn into red.

Participant: Yeah.

Interviewer: And they get more prioritised, yes, okay.

Participant: Yes, so something happened there. And we do this per group, so here, byway construction was our constraint, because it can also be for assembly, that they did not add enough work. So here, you could not blame them here, because there was no work for them.

Actually, they did, they are ready to start work, the work that is on their desk in the morning. So may you also have an idea which data we analyse.

Participant: This is, for me, the historical data that we all cover, "Could you perform, why did you not perform?" You could build quite good analytics based on this data, yeah?

Interviewer: Yes, it's very nice to see, thank you. I appreciate that.

Participant: Okay. Good. And the problem is this is demo data, you cannot get it as beautiful as in reality. Because it's really a system, so things happen, you cannot simulate this, you can't.

Interviewer: Yeah, it's like systems thinking with complex adaptive systems. You can try and make an effort to use system thinking in order to map complex adaptive systems, but you can never map a complete complex systems, because they are complex, you can never map them to completion.

Participant: Oh, no, so yesterday I had this also with a customer, and then – if you will leave out their name, then it's okay. Here, then I discussed with the teams, "Hey guys, what's happening here?" This one was very surprising me. So I sat down with, and then I say, "Hey guys, you were doing quite well" – they are just at the starting point, they started in January, February they started, somewhere like that. Yeah, the real start was somewhere in January, this was just the unfreezing phase. And then here there was a drop because it was Christmas, okay, here they did quite well and then I was not there for two weeks, and the output dropped. So I asked them, I showed them this, "Give me reasons why?" They come up with all kinds of excuses, and then I... "Yeah, but, yeah, but... This customer did not have their work ready, I could not start with it." I would say, "Oh, here, but I see you are with 10 people (inaudible 00:53:45) ....an excuse. And so why is this line not higher?" And then I said, "But what happened here?" And then they said about systems thinking, you cannot predict this, yeah. Then Mairead(?) came by, this is the one who is my task manager there, and she goes around every time, but she cannot treat everybody, so it's not every time that she comes. But here she came, and then they put, they marked work as completed at this day, because they had just not marked it as complete. So, and I really love this situation, so next time I hope, if I come, that this behaviour is gone, that I get more accurate data from them. But anyway, it tells a story.

Interviewer: Yeah, it's quite interesting. So if I might go back to our conversation within the three Vs of big data, velocity of how high velocity you receive data and where you mesh your data, and what speed. Do you try to keep up as close to live data as possible when you're reporting?

Participant: Yes. Yeah, because… people say that if I have to go to management first to ask a decision, the problem is already escalated. Multiproject management, multiproject environments are very dynamic. Velocity is a key aspect into trimming down small problems before they become huge problems. You can't wait. So velocity is important, and I want them, you also saw it already in my other example – when I mark a task as completed, immediately everything changes, the whole organisation changes. So yes, yeah.

Interviewer: Well that's good, thank you.

Participant: So if you, with that respect, velocity yes, real-time, yeah. As close to real-time as possible.

P17 May 2020

Interviewer: So, if anything is unclear, just feel free to interrupt me. So anyway, and just to begin with, I will ask you to briefly explain your exposure of AI. And this can be in a in a work environment or outside work. And it could be in a practical way or in a theoretical discussion is up to you, but can you please give me some background of your AI experience?

Participant: Well, I think probably, I'd say I'm a relative novice or more or unwitting exponent of AI. I've been involved in a professional perspective project, which uses AI for data analysis and data manipulation. And that was in relative infancy when I joined the project.

Interviewer: Can you briefly explain your project experience and introduce your role to me just quickly, in a briefly way?

Participant: Yep. So, I'm a project manager, I've probably been doing a project management role in various forms. For probably at least 12 years. I have an IT implementations background, station startups, regulatory activity, and consultancy as well. So those are a broad spectrum of project areas, sort of loosely themed around aviation or work, or authority. For the, will be eight years now coming up. And I was working for airlines for 20 years before then.

Interviewer: Okay. And that gives me some good background. Thank you for that. And, but digging a bit deeper into your projects and AI, how do you use the AI?

Participant: I think from my experience, it's been a lot to do with not really understanding the scope of what's needed to be done. It's a long-standing organization that has a lot of legacy technology and practices, which have kind of grown organically over decades, really. And at the start of a lot of the projects I've been involved with. So, it can take a long time to uncover what you're actually trying to do and what needs to be done to fulfill the objective of the project. So, it can be quite easy to be knocked off course when your scope could creep dramatically because all of a sudden, you don't realize there's something over here that no one was aware of, it was kind of a legacy issue or legacy organizational feature that needs to be accounted for. So yeah, there's kind of a breadth and understanding of the organization, some of the history of it can pick up the projects and has in the past for projects I've been involved in. So we use the AI system to manage this.

Interviewer: What is the general length of your projects that you thought of?

Participant: So, the ones I've been involved in bursaries and portfolio delivery? It's interesting. So, they had sort of one to two-year lifespans, but then some of them can be four- or five-year lifespans as well. So, you'll have to keep going back with a revised business case for the subsequent years funding. And so, it feels like those projects end up being short your one-year durations, you have to get back through the budget, a business case approval process. So yeah, I'd say probably been forebear portfolio delivery, two to three-year link duration projects. Others are much shorter. And I think probably a feature the fact that as a Senior Project Manager, we tend to get given the larger, more complex activities, which would have multiple delivers, as opposed to some of the less senior members of the team that have smaller, smaller scale projects.

Interviewer: So, I'm going to move into more questions about AI and projects now. And what kind of technology do you use to support your projects today? Do you have any specific example to share with me?

Participant: No, I think it can be useful. I'm naturally optimistic and inquisitive as to how technology can be used to support. So, I think it will be quite interesting. So, I think from a day to day, perspective, project management can have a lot of avenues administration with it. Obviously, various levels of administration in terms of the number of artifacts that need to be kept maintained, risk logs, action logs, stakeholder engagement materials, prioritization tools, and things like that. The use of AI to kind of keep on top of some of that, that kind of time-consuming activity could be quite useful. And allow the team or project manager to sort of do a little bit more strategic thinking about the direction of the project and what's coming over the horizon. Gathering tools probably seems like a bit of a not getting the best value out of AI. So, I think, probably more some of the predictive things in estimating and planning type tasks, we have a lot of capability to AI.

AInterviewer: You mention administration and predictive areas, what about project control?

Participant: Well that is also a user area yes. I think one of the one of the key things would be a cultural acceptance. And understanding that AI is there to help, it’s not necessarily there to sort of replace any people or particular functions. And I guess one of the continual bugbears of project managers is never having enough resource. So actually, you could have AI that would support filling any resource gaps, where you really have people performing roles that you could release those people to add value in other places and have AI support some of those resource constraints. So again, planning can be time consuming, some of the project support activities around log keeping and plan activities. And recording can also be quite useful.

Interviewer: Okay, thank you. Would you define scheduling and planning and control differently? Is that planning is quite time consuming? Would you say planning is part of your administrative tasks?

Participant: It's a little bit of both. So, there's an administrative side of keeping a plan up to date because plans are never static. But also, I think it's it would be useful as a point of consistency. So, if I could produce a plan, I would share with my colleagues and they would all come out with some other some different variables based on their own experience and estimates of how things would work. So, I think AI as consistent as it could be, probably quite useful to go about.

Interviewer: **Okay. Just finally, and I want to ask, about escalation and project escalation. What is the role of AI in this area in your perspective?**

Participant: And that, again, that depends on the organization. Some organizations demand much more work, as much rigor but a lot more documentary evidence for project escalation. And I think, well, it's probably the same, particularly portfolio delivery probably says about the same amount, because they're trying to work to a project delivery framework. So, you know, there are elements of the framework that we all have to adhere to when project escalates. When I've done consulting, it's a little bit looser, in terms of what's most effective or valuable in terms of the administration side of things as well. I mean, if you if I took you from a departmental perspective, portfolio deliveries, we are quite keen adopters of new technologies or early adopters. So that wouldn't turn us and proved to be a barrier and across the organization. I don't think that would be met with particularly resistance. And I think, given the strange times, with COVID we all experience in the moment, this is probably an appetite or an acceptance of change. So, if you were going to make changes is probably not as good a time as any other thing.

Interviewer: When escalation occurs, would you see some resistance or is it just go get mode from the start?

Participant: When you say escalation is about actually providing the tool to drive the project towards what we're talking about. There needs to be an acceptance towards the, towards new ways of work in some technology.

Interviewer: And do you see yourself as, as having a key role to increase this acceptance with own along in your project teammates?

Participant: Yeah, I would definitely, definitely see myself as having a key role in that. So, using the technology showcasing it, making sure secret people could benefit and demonstrating the positive side of it. And yeah, hopefully, I find it's actually delivering better outcomes or better results with the project if it proves its worth.

Interviewer: Okay. And so, if you would suggest to use data in projects to a further extent, how do you think this would be accepted in your senior level and also below you, on the project team level?

Participant: I think at the senior level, when wholly gets broad acceptance, I think you could the draw the comparison that if it's good enough to use AI to provide better safety outcomes, then why would you not apply the same logic to project outcomes, and all the benefits that that might entail. And again, the taking the long road, the broader team within portfolio delivery and the information teams as well, quite comfortable with adopting new technology. So, I don't see very much acceptance or resistance and acceptance in those areas either. I think, what I was gonna say... it is quite interesting. I think, yes it could be accepted as a boss role, but I think people will say, so how's it going to work? And what is this kind thing? I think people get into politics because they want to get really involved in something. And if they feel like they're less involved in the project or more involved in driving data to support a system, that may make people switch off to be able to be included in our project management. Does that make sense?

Interviewer: Okay, so I'm gonna ask a bit more specific questions about data, and compare data with personal experience, because personal experience is highly valuable. That's why you are in your role today. But would you say that you are taking more decisions based on personal experience, than based on data at today?

Participant: I'd like to say I probably try to split my decisions across both things. I personally would prefer to make database decisions, because I think there's a lot more evidence, than to support that. But you can't get away from your gutfeel sometimes and experience. So, I think a blend of both. From my perspective, works both ways. Yeah, probably difficult to say, I think each decision lends itself to either a gutfeel call or data driven. Really depends on the situation. I think if there was no data to support the decision, then obviously you have to make the judgment call.

Interviewer: So, how? So, in general, in throughout your whole projects? Are you happy with more decisions are taking on personal experience, which could be subjective and bias?

Participant: No, I think I think the whole project, or the whole enterprise would probably be benefit from taking more database decisions. But I don't think you can ever take the experience out of it. Just as an aside, actually, I was one of the projects I'm involved in at the moment is around prioritization of policy direction, and things like that. And just to use that, as an example of the day, we can use models to prioritize things like the sort of standard pestle, tonic analysis. And that will give you a set of results, that then what we're would, what we're going to do is provide a prioritized list of things using a system to do that. But it will go to the board sponsors,

and they'll go actually, we agree with this, or we're going to, we're going to fast track one thing, because we know, from our experience, this one is much more important. So, there's always going to be the quantify.

Interviewer: Okay. And you also mentioned now previously, that if you do have some experience that that confirms the data, you would probably, you will most likely use your personal experience if I understood you correct as well?

Participant: Yeah, and I think it wouldn't necessarily be to challenge or disregard what the data is saying it might just be to question, and think as wanting to understand this a bit more because it's powerful counted to my why my intuition if you want to call it.

Interviewer: So when your AI system and suggests a certain type of decision for your project, however your experience says otherwise. Do you have a collaborative mindset with the AI system? What is your reaction?

Participant: Probably not what I would probably use. Again, I would go back to what I said before and as much as if this if the system says this, but I'm, it doesn't sit well, with my perception of things, I would just use it as a point to clarify. And then, you know, interpret again, interpret that think about the issues, which are throwing up that suggestion or proposal and then just really understand them more than anything else. That still, it might think needs to be corrected, or if the AI system, maybe we're active on data that is incorrect, that what he wants to do is trying a different decision. So, the trouble with some of these techniques are, they're not very, they don't offer a lot of interpretation. So, some of them offer more than others. But you mentioned that it's important to understand why decisions will take. If you would have a tool that would give you some interpreted. Sorry, a way to interpret why they took a decision, I think that would is very useful. Yeah, I think it would allow people to trust the system,probably would smooth by him as well. So, people understand how it works, rather than take it on faith. And yes, with machine learning over time, it could get better and better and much.

Interviewer: So, this system where you would have some interpretability in the system? And what would you see still be the challenges in that kind of way of working with having an AI system, where you can see some kind of interpretability?

Participant: I think the challenge is probably just with early adoption, I think with anything, it's gonna take a while for people to accept and start to trust. And, over time, as they become more familiar with it and understand how it works, and see the results of some of the suggestions or decisions it's making. That will shift and people will be more comfortable and less likely to interrogate. I think it comes down to a maturity, and a need that just probably just has to be accepted. So, I mean, I'll give an example. I've never that either of us to know how to spell, an

amazing concept and say, just trust me, really wants to know why. And what's most behind my thinking around Artificial Intelligence.

Interviewer: Yeah, makes sense. Thank you, thank you for that. And so, you said there is some maturity issues, and you can't just, you want to just trust a system just because you're told to trust it. And you also mentioned before they have a key role in maybe showing demonstrating systems in your project in order to increase understanding of this technology. And are you offering any training in that sense of to explore new ways of systems?

Participant: There are some training and others training available in the data arena to comply with what it was called the moment as a couple of my colleagues in formal learning in that respect. Again, learning within our organizations is quite readily available, but it really comes down to people's time pressures and kind of what's out there. But there's no barriers, if I was to find a course I was particularly interested in, but it is, kind of led by the individual as opposed to prescribed by the organization.

Interviewer Okay. Would you say, some training in how to understand AI systems and the principles of AI would help your projects to move towards working with them as well?

Participant: Absolutely, I think if people have a much broader understanding of the workings of AI, and that kind of methodology. Then yeah, it would certainly improve adoption and acceptance.

Interviewer: So, what if a colleague of yours on a team level would say that he wants to go on the AI training course? Would you encourage that? Or would you give some other advice to this person?

Participant: No, I would probably encourage it, I would almost encourage that, especially knowing if the organization's future is on that route. Without doubt I'd encourage people to engage it.

Interviewer: Thank you. I'm just going through my notes here for a second, everything. So, if I look at the project life cycle, do you have a specific project life cycle your work after a model in your projects?

Participant: We have a project delivery framework, which has been in place for a couple of years now, it's in the process of modifying. But it kind of follows a fairly standard project lifecycle stages in terms of concepts in developing, delivering, implementing, and then sort of benefits of enclosing a standard project management phase.

Interviewer: Okay, so if you would be able to choose, when do you wish you would have or when do you think AI could help your projects. In a life cycle perspective, when the project lifecycle would you say you had most, you would have most use of AI?

Participant: I would say probably, at the early stages in terms of the developing and planning part of the project, understanding what the scope looks like. But then again the overall admin, analysis and control as you said.

Interviewer: Interesting, I know there's scope tool for software, software development. But I haven't come across that, that often. So, if I define the project face within pre-business case in the planning, and what sorry, in the scope setting and so on, and post business case. And if I understood you correctly, you would prefer to use AI systems, will you think that would be most useful pre business case in the scope development in terms of escalation?

Participant: Yeah, I think so. The business case pieces is always difficult to try and gain consistency of refining **(**Inaudible) come from lots of different sources, or different experience levels, different pieces, spaces and levels of maturity built into it. Again, it's the probably the piece that you want to nail down as early on as possible and have as much clarity and detail built into it. I think just so that the in the latter part of the projects can run more consistently and be better estimated. It goes back to that old adage of you do all your hard work and planning upfront, I think it should be easy.

Interviewer: I understand, thank you. If I may ask more about the post business case where after the scope or after the scope is set and the project has been initiated. And if I define the project lifecycle in previous a business case, and then the post business case has three life cycles, that three stages, planning, monitoring and control and closing face. So planning, monitoring, control, and closing phase, which one of those three would you say that you would be most happy of using AI systems?

Participant: I'm so sorry. Couldn't hear what you were saying, you were a little broken. In terms of the where AI will have most applicability, I think in terms of the planning and control in the closing phases. I think there's the detail of a doubt data which comes out of the planning and the closing phases would be very useful. In projects, it tends to be that that last part, which is least looked after, and people tend to want to run away from the project as quickly as possible and move on to the next one. So, any learnings or information that will be taken from that and built into the knowledge base and recycled into better decisions and new projects will probably have a lot of benefits? I think, again, showing colleagues, the benefits of sort of better data quality going into the AI post project, and how that's turned into better understanding and

decisions on projects going forward. Or the notable projects are the same, but there are some similarities that can be used. And the lessons learned, obviously, is the key thing. So, the AI can support improved lessons learned and better situations and future principles or policy **(**Inaudible).

Interviewer: So where does the mindset of having a more developed a data management sit right now? Do you have? Is it within your PMO? Or is it depending on the people within each project, their own personal agendas, if they think it's important or not? Sorry? (poor wifi connection)

Participant: You asking about data management?

Interviewer: **Yes, sorry. Yeah, I do see my network is bad. I apologize. I can ask my question again, if you hear me now. So, what I so what I wondered was, does data management now sit within the PMO?**

Participant: So, I think if I understand, the data that for projects at the moment is pulled back to our PMO. And they'll use the data that comes from each of the projects to inform **(**Inaudible**)** reporting and metrics. That's not necessarily fed back into the projects again, so I think there's probably a loop there that doesn't need to be closed.

Interviewer: Okay. I apologize for the poor connection So the PMO is where the data management sits today. However, it's not your biggest focus, if I understood your answers there. Would you say that you are happy with the data management as it is today? Or do you see an ambition to develop this further?

Participant: I definitely think is an option to develop it further. Yes, definitely an option to develop it further. The feedback post project could be better. And I think part of that is not necessarily the lack of data information, but it's probably the time constraints issue as we have a large portfolio of work in the pipeline. So as soon as we are off one project with pretty much. Well, you're overlapping looking at other projects as well. So, there's a time constraint to sort of, sit down and absorb those lessons [Inaudible) I think I'd have to see how that works. Actually, I think I can't see, having a dedicated team working on project data. To my mind, it must produce better information and (Inaudible) 100% on that, I will be skeptical about. (Inaudible) within our organization, we have a lot of people that wear multiple hats, unfortunately, so. But I can't see how that would be a bad thing if that were possible. I was also a bit disconnected a few seconds in middle of your answer, but I understand that if I just can summarize your last question your last answer there, you would be a bit skeptical for it to just happen without any other, just like that, but if it would happen, it would obviously be positive towards it.

P18

Session 1 September 2020

Interviewer: It will be completely anonymous and coded afterwards. So, you won't be able to be recognized in the transcription. I will talk about project managers behaviour with AI and escalation. I briefly explained this before. Yeah, so I don't think I have anything more to introduce. Do you have any questions to me before we begin?

Participant: No, you can begin. Throw questions at me. I'll do my best.

Interviewer: The key here is for me to hear about your perspective. So, I just wanna hear your words and your perception, and how you would feel about using AI, and these tools in project management. And so, before I share my view of AI, and so can I just ask for you to share your perception of AI? And what do you, what comes to mind when you hear about the term artificial intelligence?

Participant: It's something that you know, removed, while it's a process that removes the need for a human being. To be there, it's a robotic kind of process. That, you know, it's a program that's built for the robot to sift through the data and find answers that you need, potentially, there's different types of AI, so you know, yeah. It's that automation of robotic process, you know, you like a chat bot, you type something in that regurgitates information at you. It's great when it works, less so if you don't get it right.

Interviewer: Yeah, thank you. But I just want to hear if you had your own perception, because that's what I feel about artificial intelligence. It's in the perception of the individual. If something is perceived as intelligent device, it could also be seen as AI. But this is, then there are these technical terminologies and definitions, which I won't use here today. But thank you for sharing that. And just as you say, I use

artificial intelligence as an umbrella term for different wide spectrum of technologies all the way from quite simple, but still could be advanced chatbots, to machine learning and deep learning as well. But lately I see it as project managers can use it for early warning. Can you please briefly explain your exposure to AI if this has been in the work environment, or privately or is this a being practically or just under discussion?

Participant: I think we're quite behind in automating processes. In like, normal day to day of life, as much as you get exposure to as I said, the chat bots, you know, different apps that do machine learning, Google, and Microsoft advancing in the eye, it's all about data. gathering and

you know, analyzing and yeah, so the analogy for early warning and another perspective is a nice view to it.

Interviewer: Thank you for clarifying that. Can you then explain to me your current project roles so I can get some context of what you are doing today and how long you have been in this project role?

Participant: I'm a junior project manager. And, you know, it's managing stakeholders, milestones, actions, project plans, and just making sure that it kind of scrap as a juggler you have like 15 balls in and just making sure that it all kind of moving and ticking along. People are doing what they're supposed to do. And yeah, it's all kind of fun when it's on time and on budget. The system helps with that, give another perspective, making sure the plan is on time and so on.

Interviewer: Do you have any previous project experience before this?

Participant: Yes, I worked at a law firm for two years. It's project coordinates, work for another company before that as a project support.

Interviewer: Okay. Thank you. Is it reasonable to make that assumption that not all of your projects do deliver on time and budget and quality?

Participant: Yeah, I mean, we're not robots. So, yeah definitely. It's just human element. Yes, things go wrong. I think it starts from the beginning, you need to make sure your requirements are set out properly. That's one of the biggest things that you haven't got your requirements gathered and documented appropriately. AI can't do that yet. Something else can creep up later that you know, is going to change your scope, potentially, you know, increase the time. And obviously, that can affect the quality and budgets.

There's also quite complicated landscape with suppliers. So, you can have multiple suppliers, then you're dependent on their delivery. And from experience of a previous projects, that's where we kind of that the issue arose where, what they thought they're delivering, and what we thought that delivery kind of didn't match up so that contract management and contracting hasn't been as robust as probably could have been. And that supply management process probably as well. But also, their ability and their expertise is probably not it wasn't as advanced as we hoped. Plus, there was another third party who also they subcontract to another person, who subcontract to another person, and then they just kind of get a little bit complicated. And it's that finger pointing, it's their fault. It's their fault. It's their fault. You know, that complicates it a lot. But also, internally, things move on, you know, you if you do a project for a year and a half, you know, what you said you want to do? Six months later, things can change. And you know, people change their minds. And that's not what we want anymore, we want something else. And

that's kind of that will affect the delivery as well. So, there's a lot of different things. For example, as to the projects, I was working to the phase three, which was implemented in the third product in SAP, Corona hits, we don't have any money, it has to be closed. So?

Interviewer: I can imagine, a lot of unexpected emergencies.

Participant: Things happen. There's multiple events.

Interviewer: So, if I if I may ask you to, to identify some areas prior to escalation, which you would prioritize them in order to see some increase of project success. Are they the same as the reasons why they fail? Or wouldyou choose some other areas to focus on in order to, at least increase the chance of success?

Participant: I think the discovery phase needs to be a little bit more in depth. Because a lot of the time from previous experience but also talking to other people that tends to Be that product in mind, when you when you become starts a project, rather than thinking, you know, a little bit more about requirements actually what you need that, you know, they think, Oh yeah, there's that product and let's get that. So rather than actually understanding what's on the market and maybe trying to see if we can build something that's fit for purpose, it's things like that, you know, it's a bit more kind of time spent in discovering, I think would be a little bit more helpful internally, and nailing down a business case as to, you know, why are you doing it? Yeah, that's it. I think that's something that's going to improve the delivery.

Interviewer: That's good. Thank you. That's interesting. So, if I may ask a follow up question there. And what is the reason then that, you can explain for me for not, I'm not well, for me not understanding completely that the process and that happens, if it's a project is accepted? Is that for time pressure? Or is it perceived as everything is, we know, everything we need now, so let's continue? Or is it some other reasons for why it still moves on and becomes initiated?

Participant: Guess it depends on the project, sometimes there's a, you know, depends on the burning platform, you know, why are you doing it? It's a change in legislation. So, you don't like we're regulated, sometimes we have no choice, we have to do something. Because there's a change in in legislation when you have to adapt to it. So even if we, our current tools are fit for purposes, he won't be in the future. It's the adaptability. Sometimes, you know, the product is running out of support. So, for example, the reason why we implemented a difference, finance and HR system is that finance systems, going out of date, the downtime was high, it was no longer supported. It was just a matter of time.

When it's going to fall over, so you know, you kind of have to do it. Yeah, yeah, it just depends.

Interviewer: Thank you for clarifying that. So, I'm gonna ask a bit about administrative tasks and escalation. You mentioned before that AI can be a, some automation process and leaves the human side to do other things or so on. But just to get an idea about your role today and the time you spend on administrative tasks. And how much time would you estimate roughly that you spend on repetitive administrative tasks in your current role that can escalate a project?

Participant: As a project manager? Like 70%? 60%, 70% of our life is updating plans and lucks. Yeah, setting up meetings. It's repetitive stuff.

Interviewer: Although they are repetitive in the sense they are, the activity you do is unique per project?

Participant: I would struggle to our struggle to imagine how that can be automated because it's all very project specific. It's a challenge to see similarities in projects, speaking from personal experience. We want to believe everything is unique

Interviewer: So what is your perception to data?

Participant: This is why we do our best prediction at the end of the project [project progress], then we have more reliable data [project data generation]. When the data is created we can make better predictions, i.e. also trust that the AI model perform well [trust in AI model]. But not everying come in this way some changes is reported in other channels.

Interviewer: That's interesting. So how does these changes that you do come in? Do they come in through a system or through manual communication?

Participant: Through communication. So, we have a project meeting that you discuss things, discuss progress, emails, fly into your inbox? You know, we've done this, we've done that. So based on that information, that kind of filters through the day, through the week, he updated plans and logs and yeah.

Interviewer: You mentioned previously trust in the model? Can you expand on this?

Participant: Yes well I need to trust that the model is showing accurate analysis, we have some issues when the team doesn't trust the model due to poor data or wrong data. Sometimes I believe I have the correct updated data but the model doesn't, so I will not trust it making best decisions.

Interviewer: Thank you, and so, based on your perspective. You've mentioned it before, and a bit skeptical sometimes. But also, I'm not going to put words in your mouth. Can you share your thoughts on your perception of if AI in projects, can you expand on this?

Participant: I'd love to see being used better. It would be a fab idea if that makes our life easier if it makes, you know, certain processes more automated. But because it's not like a central. For AI to work, you kind of need to have some sort of a central data deposit repository. And it's very difficult to do that with project managers, because it's different styles, it's different people, different ways of storing different places of storing information. So, unless you bring kind of a central bucket where all the information is stored, I don't see as being able to pull that information out of it easier. So, kind of that's why and the way the information is recorded is different. There isn't kind of that structure, or kind of naming conventions and all that. So, it needs to be very rigid, set up for it to work. And knowing how different people are and how differently they record everything and process it, it's going to be a hard setup. That's purely from my opinion.

Interviewer: Do you think you might have touched it a bit, but not gonna make my assumptions? What is the reasons for this, then? Is this an organizational issue?

Participant: Maturity. Organizational maturity.

Interviewer: In AI or project management.

Participant: Just generally, in technology as well, you know, government affiliated agency, that is the regulator, you can make your own assumptions as to the demographics of the organization, what it is, how welcoming they are to change and innovation. So, yeah.

Interviewer: So, what would you say is, your within your department and your colleagues and the people you work with, what is the perception of, of using new technology and acceptance of trying new systems?

Participant: I'd say, portfolio delivery or any kind of projects, function in any organization would be the one that was welcoming to change to new technology and is welcoming to use new tools and any way that we can make our life easier and organization. So internally, I would say it will be taken, you know, welcomed with open arms. Its automation is something that we've been trying to put on the agenda in the organization, talk about it, and push and get some funding to, you know, do some proof of concepts, but it's slow process. So yeah, we would, I would love it. Absolutely. Go for it, you know, I'd say bring it on. I'd say for the past for the past four or five months, there has been a discussion to introduce some sort of AI in other departments as well.

Interviewer: Is the discussion held in different departments or in different hierarchical level, how would you say that?

Participant: Discussion that portfolio delivery has been pushing with the forces above, as you say. We did something like automation blueprints where we submitted a paper of ideas as to

what we could automate within the organization or we could work on and the efficiencies we could see, you know, interesting. By the end of day, it comes down to money, you know?

Interviewer: So, if you can, I don't know, if you if you're allowed or if you're able to recall what just quickly, what kind of areas did you include in this report or?

Participant: Yeah, there was a couple of ideas to press more around finance team, because that's the kind of the biggest efficiencies that we could gain is in the finance team to get them some, help them the scheme of charges especially.

Interviewer: Thank you, it makes sense that finance and numbers, the data is there already, so we can extract the data easily.

Participant: The issue with any kind of project or any kind of new technology and innovation, especially with robotics is you don't see the benefit straightaway? Yeah. And it's an old school organization way, I'm spending 2 million, I want to see 3 million return. And if I don't see it immediately, I don't want to do it. So, and with the I have to kind of do a proof of concept, you have to show that it works, what efficiencies, there are not necessarily financial efficiencies. And that's why it's not as quickly as quick to you know, embeds in the organization. It's not people are not as forthcoming to say, Yes, I think we are in a stage where we want to, and I think it's we want to try and undo the proof of concept.

Interviewer: I understand. Thank you for clarifying. I might come back to these topics a bit later. I'd like to ask them a bit more about data and.

Participant: It's also capabilities, and it's what you thinking, it's that deciding the approach. Do you outsource it pay someone to do it for you? And is basically you chuck the money away and you don't have any capability in house? Would you build their you know, Center of Excellence, you bring in your own developers own, you know, automation specialists and build that capability in house, which is then continuously proved. It's, and the setup of that pieces is costlier than paints the third party to put something off quick fixes and.

Interviewer: Thank you for elaborating more of those thoughts. Like just in context with AI as you are aware, data feeds AI and AI is dependent on data on the output. It could be biased and it could be more non bias in that sense, but and does your organization encourage the discussion about data and project escalation?

Participant: My own personal skeptical opinion about is no but, If I trust the AI model [trust in AI model] I feel more secure to take action and follow the recommendation [willingness to take corrective action]. This [trust in AI model] can change as the project goes on, but I usually have my assumption from the planning stage [short term delay], and in the end it's dependent on if

the team and I want take on plan B [willingness to take corrective action] [medium strength feedback].

Interviewer: So, you said you're a bit skeptical? And why is that?

Participant: Just comparing it to my previous organization. What extending with the data was talked about, and we had the data management program where we're talking about data maturity, andyou know, you start from the bottom, you know, you have to make sure your data is right, it's properand accurate, and only then you can build on it, I've not had conversations like that here.

Interviewer: So, so I understand you might have insights from previous experiences. How about your project role? Is this some way? Do you see potentially areas where you can improve the baseline on data, like you said that the graph is step one?

Participant: I can always improve thoughts in any projects is. Yeah. Because like, you know, there's this example, a couple of objectives in my current project is the fact that we can't access the data, or the data is held up with a certain person, at certain points and who are not releasing it, we can't progress. So yes, you can certainly improve that how it's accessed and stored. To make it easier. Yeah. That data from another department not being shared with another. If I decide to follow the AI [willingness to take corrective action], I see what the issue is [rework discovery], at the same time the AI model learns constantly from the identified delays [project data generation] and will improve for next time. We do have issues with feeding and training the AI with the newest information such as the latest interruption [project overruns], leading to the analysis is not always up to date [misaligned goals and objectives].

Even within the same department. So, for example, we need to create a strategy for. I'm going to bore you with HR stuff, we need to create a strategy with four critical roles in the organization. We do have somewhere written down what the critical roles are, with the person who requested information from hasn't provided them yet. They can't seem to find the time. So, if that information was held in somewhere central point where any HR person can easily access that. And it's not, you know, ring fenced by anyone, just because it's sitting in someone's inbox or computer, then, you know, it's easier for us to carry on the work.

Interviewer: I understand, yeah, so it doesn't, you're lacking the central sharing point right now where you can access it easier. Would you say that this is generally, let's say this person who holds this data in a in an inbox somewhere. Is that a general understanding that this needs to be improved? Do you think? Or is it quite content as how it is right now?

Participant: From my perspective, I think it needs to be improved. That's, you know, the whole situation is quite frankly, is rubbish. What I think a lot of people wouldn't even put second thoughts. And that's how we've always worked.

Interviewer: Yeah, leave it like that. And I'm going to ask you about data and personal experience. So, if I ask about escalation, without making any assumptions, what grounds do make any make decisions today? Are they based on data or personal experience overall, in general?

Participant: I think it's 5050. And so, it depends. Certain things can make a decision based on data for certain things, based on your previous experience. We are quite biased creatures by nature, people like to make assumptions about things? So, I'm guilty of the same. Just as people can be biased data can be biased as well. So?

Interviewer: So, what are your thoughts then? That decisions are slightly while 50 50%. So, it's quite even there. But would you Are you happy with this decision? Or would you like to improve the database decisions that you make?

Participant: I think that you will be better to improve because I'm quite an analytical person. So if the data shows that, you know, this is the right way to do it, then absolutely, you know, if we can improve the decision making based on data, I think it will be better because then there'll be less assumptions, less wrong assumptions, less biases, hopefully. When my team can make sense of the AI model output, and also explain this to my senior management [AI explainability], then I feel more support from my management colleagues [trust in AI model].

Interviewer: I understand. Thank you. That's interesting. So, what if you would have? What if you would improve the data in your project then as a scenario? And you would have a data suggesting one thing but your gut feeling your experience suggests something else?

Participant: Okay, so check the data is correct. Or if there is any bias in the data? Because if there is, then obviously need to make that judgment. The whole idea is that, you know, you have your data, you have the robots, you need to make sure you have some sort of process to make sure the data is correct. Yeah, I'd say I'd say, probably double check the data first, before I make a decision.

Interviewer: Double check the data. And what do you mean, double check the data, what do mean with that?

Participant: You would require some interpretability in order to understand the data to, you would like to see where the data come from, and the sequential part or how it comes up. When the project is in need of a fast decision, we don’t have time to wait and update the data, we do

need to improve our data management and processing but that's another question, anyway we don't have time to update the AI and it means the team and I sit on the most accurate information to make an informed decision [misaligned goals and objectives]. Leading to we do something else than what the AI suggests [override AI bias].... I cannot follow an AI that I don't trust have the correct information [trust in AI model]. I would define the project lifecycle in two phases, to begin with the pre-business case and post-business case. So in the business case you need most importantly the requirements that is most important, what's the scope, what you actually want to achieve, what the benefits are going to be. So, it's that pre business case, and actually having it all written down is important.

Interviewer: Thank you.

Participant: It's defining it ahead of time. Because then you just, it's just a different interpretation, isn't it?

Interviewer: I understand, thank you. What if I, if I then go into the post business case? I'm not sure exactly what terms to use usually do that, you usually use for this for these spaces, by my perspective, I usually use two terms planning and then monitoring and then closure face, but feel free to use the your own.

Participant: Yeah, you can do like initiation, planning, delivery, closure, it depends each (Inaudible) their own names to it.

Interviewer: So, based on the types of use after that business cases is decided and the project moves on, where in these phases, would you suggest needed to be improved the most to increase the chances of your project success?

Participant: The delivery and the post closure, business change. That piece that, you know, handover to PAU and business change and continuous engagements.

Interviewer: So, can you elaborate a bit more perhaps though, why do you say delivery to begin with?

Participant: Okay, you know, I'm gonna I'm gonna change that, because that's the initial planning. I guess, rather, I'd say planning because delivery suffers from poor planning. Yeah, I think planning needs to be done better, more realistic.

Interviewer: And that if I may make an assumption that that goes back to your requirements that you mentioned before as well.

Participant: Requirements, availability of resources, the capacity. Yeah.

Interviewer: Perfect. And if I don't ask you a bit about the closure face, I'm sorry, I can't remember that term you use.

Participant: Change Management.

Interviewer: Yes, what do you see as the biggest challenges now why it's not working as it should?

Participant: It's not done properly, not always. It's sometimes, because in traditional project management, business change is not part of it, you know, it's, we come in, we deliver, off you go, nothing to do with us anymore. But the whole piece of training, you know, engagements it needs to be thoughts of a little bit more.

Interviewer: That's good, thank you.

Session 2 May 2021

P19

Interviewer: Explain your experience in project management?

Participant: I'm the project manager for our system development, I've been here for some time, about 2 years. Did other stuff before that within various project delivery team. I have had lots of different roles, deep into project teams, delivering milestones, and the other spectra on programme level, today I am not sure what the next step is.

Interviewer: I understand no problem. Can you talk about your experience in AI?

Participant: I am not a programmer so not much practical experience.

Interviewer: Do you use AI today?

Participant: The organisation does and the development team, we state we do it. It works pretty good.

Interviewer: Can you expand how you use it?

Participant: We analyse our codes and it uses AI to identify different aspects of scope and requirements in relationship to our coding. In different volume, some say it may not always be AI, other time I've use machine learning for different purposes to manage large infrastructure projects so that would definitely be AI I'd say. It runs parallel with the project, also in models, or BIM if you are familiar with this? But when you explained beforehand about project control and AI analysis I thought that is pretty much what we are doing but we refer it to risks, but it controls any area that we decide to**.** Yes definitely, it is great way to use data and data analytics and data scientists, they really live for this and it is really making a difference and will do for a long time as long as we have the data that we need.

Interviewer: Thank you, I appreciate that. Can you say that it is part of project control?

Participant: Hmm well we control our projects through reporting and status reporting. The data team is central for us, it not only one person or navigated to one single department, they are in every department and everywhere but we have worked a long time with project data and I think that it is going well, nothing is perfect. They get it wrong sometimes too of course but it is a interesting to see where this can go. But to answer your question we have a reporting central, maybe say a PMO but not sure, we don't use that term really but other places I've been at would refer it to this term. The analysis is made according to the status, it gets a status, a colour, red, amber or preferably green of course. We try to be honest about our status**.**

Interviewer: Wow, very interesting, does the project get a status by the PMs and the team as well or is it only from the data analytics, or the PMo that you mentioned?

Participant: We also give our input, we don't solely go with whatever the AI states. The team can say what they see also and it is an accumulated effort to see what the best direction is.

Interviewer: Is the AI used for project control?

Participant: Depends on how you define it, I guess yes but we don't use this language**.**

Interviewer: I understand thank you for explaining. Another part of my research is on escalation and project escalation. Is this something you have experience in?

Participant: Well I guess so, I can escalate a situation a conflict with the team or stakeholders, the project can also escalate.

Interviewer: Yes I refer to the project escalation.

Participant: Ah okay, well basically we all just wait for the project to escalate no? It's a matter of time really.

Interviewer: Is the AI used for this purpose you'd say?

Participant: Used for escalation?

Interviewer: I mean used for identifying and assisting with decision-making during escalation?

Participant: Identifying yes but not really the decision making.

Interviewer: How is your reaction to the escalation when it comes from the AI?

Participant: So the AI lets the team know if something is about to happen. But it doesn't ring the alarm bells. We take all the decisions**.** It is based on a scale, sometimes we don't have to something right away.

Interviewer: Is it an easy process to do? The decision-making?

Participant: Easy? It's never I'd say hehe [laughing], but it works most of the time I think, we haven't done it for ages so not many projects have ended, they are pretty big, they have a large scope, so not many have been completed, but the timelines seem to hold better these days, that's my perception at least.

Interviewer: Okay, interesting, do you measure the success of the data team's analysis? You said it's your perception?

Participant: Well we have a major direction that we are taking, data and AI is the future, we work towards this, and we haven't been able to measure the milestones set for this, it's a direction the company wants to take, is the best investment? I don't know but it is exciting.

Interviewer: I understand, what about other phase of the project, you said you do analysis of risks, and it can be perceived as control, what about other project phases, or areas, is AI used there?

Participant: Hmm, not sure really, you're in academia so I understand you want to define everything, we say we do risks, and I guess this can be anytime in the project, doesn't have to be in a control or what ever phase.

Interviewer: Can you expand on that a bit more please?

Participant: I mean it doesn't matter when something happens, we have risks all the time, we always analyse risks, we may not have data for the data analytics team to perform their analysis, but it is always necessary. I guess what I should say is that it depends on when we have data. So to simplify my answer. When I have data, I am able to get help from the data analytics team.

Interviewer: Thank you for that.

Participant: Oh sorry I have a phone call here that I have to take.

(interview is stopped due to the participant have to leave)

P20 January 2021

Interviewer: I need to place it underneath them. Thank you. So, we discussed a little bit about AI in September, but just as a reminder and as an introduction to this conversation, that's a very broad question. And in your own words, what do you think of the term Artificial Intelligence? What comes to your mind when you hear this term just in general?

Participant: Gosh, is that a tricky one? I would think it's, it's something a non-human way of analyzing interpreting data, and giving some outputs off the back of that would be my kind of initial thoughts.

Interviewer: Though, yeah, it's a very broad topic. And I try to do my research as to understand acceptance of AI within project management. And it differs, my oldest reasons from usual business as usual, because of the structure, and uniqueness of projects, so I'm gonna I, I use the terms very lightly and very high-level terminologies. But I'm happy to discuss machine learning these things as well, if you have any insights into this, if I mentioned any terms that are unclear for you, just let me know if I can describe further. And feel free to interrupt me anytime, if you have any questions. And so, can you briefly explain your exposure to AI technology, in general. Has this been in the workforce or privately? What's your exposure to AI?

Participant: I have been exposed to it in my work, but I'm sure there are lots of things in the world that actually utilize AI to some definition. You know, for example, does my smartphone have an element of AI and some of the applications that are on it that I don't know or wouldn't think of, and I use it. From a work perspective, our processes is a very manual using fairly standard kind of Microsoft applications, particularly when it comes to the project delivery side of things PMO. Across the wider organization, obviously, other applications systems use which can be bespoke to the particular thing with those bits, the organization of doing particular and data management data capture that sort of thing. But I can't really speak to those, I can only speak to that. The things that we use are partly AI and party operations. We're a relatively new into the organization. So still growing, still finding our feet, continuous improvement, all the rest of it. But, yes, I would say that we routinely have use of AI, in the things that we do within my department.

Interviewer: I understand, thank you for giving some brief background for your AI exposure. Can you just give me some context to your current project role as well? What's your current role, and how long have you been in this role?

Participant: I'm currently the head of the Project Management Office within our department, which is portfolio delivery. So, my function is to assure project delivery. And, that's in terms of kind of make sure that the processes are fit for purpose that they're being followed. There's a financial management aspect in terms of managing our departmental budgets, I'm making sure that projects adhere to the financial processes that we have in place. There's a lot of reporting that goes on. So, acting as the conduit for information that's coming from the projects, consolidating information, interpreting that data to provide information to stakeholders. Good sort of standard PMO type functions. And additionally, we pick up the kind of more mundane business support type roles that you would get in a business area. So administrative tasks like raising purchase orders, or booking training or, you know, things of that nature. So that's my current role. And I been in it for a year and half. And prior to that I was a project manager as well, for a year and a half. So, I kind of poacher turned gamekeeper almost.

Interviewer: Thank you for clarifying that. I just wanted two follow up questions quickly on that, you said that the current PMO hasn't been active long. How long has it been actually?

Participant: Well, I mean, I suppose it's for what's very long mean? The portfolio delivery has been around for about three years, three and a half years. So, as a sort of business function within the organization, it's relatively new. And historically, change was delivered in pockets across the organization. And now that still continues to this day. But portfolio delivery was an attempt to draw together some of the change professionals functions, ways of doing things into a single place, in order to provide some consistency in terms of approach and terminology be delivery, and a little bit more transparency, particularly at the kind of executive level. So, we're still on that journey, you know, but going from a standing start, you know, we're not where we want to be, and where I think most people would recognize we need to be. But we're in a much better position than we than we were a couple of years ago, when all this started.

Interviewer: Thank you for clarifying that. Just so I understand you, you were speaking about project and AI maturity now, where you're at a better place than you were before?

Participant: Yes, I'd say, I suppose, because I look at things in terms of processes, the ways of working, ways of doing thing, governance, that kind of stuff. So the kind of framework within which we deliver, that's the mindset, I'm looking at it from where I, you know, always looking at how we can continuously improve, which is a slightly different spin, I think to someone, if you're a project manager, looking at how you deliver your projects, you probably less concerned about governance structure and process as long as you're achieving your delivery. So, you know, if I'm doing what I need to do getting the business outcomes in place on time to budget, then that's great. I'm one, wherever whereas for me, it's a slightly different angle.

Interviewer: Thank you for clarifying that. That makes sense to me as well. So, I'm gonna offer a bit more about my real questions now about AI and this topic. But first, I'd like to hear a bit more about failure reasons with CAA, is it fair enough for me to assume that some of your projects do fail?

Participant: Yes. Some do fail or maybe they don't fail to do to the extent where they're stopped necessarily. I mean, there might be an argument that they should have been stopped, but they certainly overrun in terms of time and considerable overspend from what was initially assumed the cost would be absolutely out.

Interviewer: So, from your experience in order to increase the chance of project success, how do you adapt your AI analysis?

Participant: I think one area would be a better understanding when you're putting together the initial estimates for the delivery. So, you know, we might think the project's failing, because it's actually costs x not y. But how did we get to the y cost in the first place? Why assumptions? What we making it our planning? What lessons were we incorporating when we were looking at building the cost model? To, you know, as part of the business case? Time frames, were they realistic? You that pressure between the need to get something in on a certain time versus the realities of actually, well, you may want it in in two months, but it takes three months to do. So, you know, sometimes the default is, well, we just say it's gonna take two months, and then we get to the end of the second month, surprise, surprise has not been done. So, I think there's. Yeah, there's that bit around the initial estimation, and planning, in order to give a realistic view of how much investment is needed to deliver the outcomes. I think secondly, would be the transparency and regular review. So, having a way of showing progress, showing issues, and being able to highlight those and flag those early, to allow early intervention to fix issues, as opposed to looking retrospectively back at something to say, Oh, well, now we're over. And now what's the problem we want to we want to avoid the problem in the first place would be my view. And that requires having data and a way of presenting that information to inform decision making to take remedial action. So those would be the two things.

Interviewer: Thank you very much. So, in rough estimate, how much time would you say that you spend on administrative tasks in a typical project?

Participant: As an individual, I wouldn't routinely be involved in in the detailed project delivery side of things. And from my team's perspective, there are there are kind of two activities that we will undertake. One is the assurance side of things, which is fairly standardized. So, there will be a monthly checkpoint review with the project manager to assess the kind of health of the project against the framework that we have to delivery and review the kind of financial position and that

would be, here the AI is involved in some parts. And then ongoing sort of attendance of project control boards and things like that. And then there's the other side of the activity, which is actually supporting the project. So, I have some analysts who do that kind of assurance activity, and we interpret the AI and all other data and input we have. They're looking out within to the project. And then I have some project support, people who would be embedded as part of the project team to do administrative type of things.

Interviewer: So just to clarify the decision you make, are they mostly strategical or operational in that sense of project?

Participant: Probably more operational. So, they kind of strategic decisions for a project, I think will generally be made by the sponsor or sponsoring stakeholders in terms of which direction the project needs to take. Or if it's not, then it could be escalated to the group above, so are kind of senior executive level in terms of providing strategic direction where required, it's not my role to set the direction for the project, my role is to provide the environment that the project operates within. Does that make sense? So, whilst I could say, some of the decisions would have be potentially strategic in nature, i.e. if we were to change the way that we managed our investment decision making process, maybe that would have a strategic implication, but I doubt it.

Interviewer: So, asking a bit more about specifically AI. What role does AI have in your projects?

Participant: AI is incredibly useful for us I mean, particularly for my function, which in the ideal world, pull together a lot of project data, we have some data in the AI analysis today but not all. And be able to manipulate that to present the data back to decision makers is very useful, you know, these are some areas that we want to bring your attention to even more. So, become even better at identifying issues or patterns, which could end up with issues, and then being able to suggest some effective approaches to counter those, we are not there yet with the appropriate mitigation or effective approaches, but we are working towards that as well. And a way of interrogating a lot of data quickly, effectively. Not just on the project level, but from my perspective, importantly on that on that portfolio level. So, looking at lots of different projects and trying to understand patterns and synergies across them to give some insight at a higher level.

Interviewer: Thank you. Can you explain how the AI analysis is used today?

Participant: Yes sure, we receive the report and then we have to interrept this as any other source of information. Just like a colleague or team member have input or suggestion on the way forward, use the AI as an additional resource. It may say do this or that.

Interviewer: Thank you for sharing that. Very interesting to hear your thoughts. How is the data structure you receive today?

Participant: Massive, you're probably just put our head in our hands. Our data is clunky, I think because the expression, our raw data is captured in different formats, we were trying to consolidate the data into essentially a spreadsheet, some of the key data points that we need to track and want to track. But some areas are still very much a work in progress. So, data would be, the bulk of it would be at the project level in various project documents. Sometimes it's a project spreadsheet, which the AI tracks or a project spreadsheet that tracks the risks and issues of the project level. So because we have different quality of data it is sometimes difficult to verify the data quality and the analysis.

Interviewer: Thank you for clarifying that. Thank you for clarifying your data structures, it gives me a good overview.

Participant: Just to go back. Sorry, just a while I think about it structure. We do capture. So, we use SharePoint Online to be our kind of data repository. So, I probably I don't want to sound like as negative, perhaps as I'm coming across. So, the data is captured, it seemed more or less in one place on our SharePoint site, and you can find it. But it's not, it's in multiple different data sources within that one place. So, lots of different documents, as opposed to a single massive data source that you can then interrogate. That's what I'm driving at. So, it's you know, it's not scattered all over, you know, it's a module or it's a stack of papers on my desk, or whatever. It is stored, and retention periods that apply to us and the rest of it. It's just it's not a kind of wonky. Strike across.

Yes, I mean, it's fairly intuitive, you see, you could, you could certainly find your way relatively easy to a project, the project, (Inaudible). But the way that the data is structured on a project site will vary. So there, there's a lack of consistency. So, it's not like we have this folder, this folder and this folder, and all the business cases always go into this folder. And that's the same. That will very slight lead, depending on the projects. But they all have a business case, they should all have the pitztal data, they should all have their risks and issues workbooks stored, there is just it might be that some site might be structured in a slightly different way, depending on what the project is.

Interviewer: How dos the data quality affect here?

Participant: Yes, absolutely. So, like all these things, the decisions or any you know, if you're making them based on data, they're only can be as good as the quality of the input the data that you're that you're providing. So, you know is the adding crappy data and crap will come out type of scenario. If you if you're not putting quality data in, then you're probably going to get some

poor recommendations. So yes, the data quality has got to be reliable, got to be consistent and all our good stuff.

Interviewer: So, can you explain the decision process of when you receive a report from the AI which requires you to act?

Participant: Yes of course. So first I want to make sure the AI has the correct data, as I explained the data structure is sometimes clunky, but we have to do with what we got. When the report states we should look into a certain area, there are sometimes conflicting views. We have situations when I have high confidence in the AI, and times when I don't think it is doing a very good job.

I mean it would be better if the team, myself and the AI all come with the same conclusion, but this scenario [when AI and PM is not aligned] is not always bad since it provides alternative perspectives and identify delays [rework discovery], which I think in the end is positive as long as the disagreement is rational [override AI bias].

Interviewer: Thank you. Would you say that your decision is dependent on a few specific factors?

Participant: We have a structured decision process that we follow, but then we are only humans, and the structure is just as good as we are able to stick to it. But for example I need to believe the report is correct in order for me to act on it. So trust in AI is a big thing, not only for us, I mean I've read that it is also a factor elsewhere.

Sometimes the AI and myself have different conclusion [override AI bias], and the reason for this is we have different sets of skills, but also we have different information [misaligned goals and objectives]. You can then understand I have little to no confidence in the AI output [trust in AI model].

Interviewer: I understand. I'd ask a little bit follow up question on this. Can you explain how you trust in the AI model is affected?

Participant: Hmm okay, what do mean affected? Like what makes it better or worse?

Interviewer: Yes please, can you expand of that?

Participant: Okay, yes, we I need to trust the AI in order to follow its report. I trust the AI and then I can make a rational choice what to do. The model is not perfect, so there might be sometimes I know that the AI is suggesting something when actually the data or the parameters

are not up to date. Our sponsor or client will not accept us relocating resources [willingness to take corrective action] if the model is not used with confidence [trust in AI model], so essentially we all have to trust the model is giving us results we can use and trust.

Interviewer: Thank you, what else affects your trust in the AI?

Participant: Well, effectively it is how the AI has performed before and my experience with the AI. I have seen the AI become better in and also become less accurate. If I have low trust I don't want to follow the report, but when I have high trust I do feel more confident, or assured, in the AI. It doesn't matter much if I understand the AI model if I can't convince my team members what is happening in the project [AI explainability]. Because I am accountable in the end. In some projects, the sponsor has not understood the deep learning model which has created some upsetting scenes when the project didn't turn out the way we wanted. This has led us to use perhaps simpler models where we can point at the fault in the AI model. This affects the trust in the model [trust in AI model]. It's the same with trust issues, if I cannot understand the AI output [non-sufficient AI explainability], I am more likely to go against the AI [override AI bias] if I believe we have better analysis and information somewhere else.

Interviewer: Thank you. Is there any specific AI models that you prefer to use in these situations?

Participant: Yes, well, I am not the expert on different AI models. However I do know that we have some reports with very good understanding of the AI, and some other where we cannot understand how the AI makes the analysis. I believe this is referred to interpretability of the AI. There are also the level of experience from us, do we have the skills to interpret the AI? Not just anyone should do this.

Interviewer: Can you explain further about your experience in AI interpretability?

Participant: Yeah sure, I mean interpretability is important when we make our analysis of the AI report. We also use the term explainability. It is the classic AI black box problem, the more advanced AI model the less explainable the model is typically. I sometimes ask another project manager or colleague for a second opinion, I do this mainly to get their input and perspective. But also myself, if I have more experience [personal experience] then rest of the team, I will be able to bring another perspective [outside view] and identify when things go wrong faster [rework discovery]. Okay yes here I can expand on the trust you asked before, I fell the higher level of interpretability the model has, the more I can trust the AI report out put is accurate. I can then explain to other team members or stakeholders why we are making this decision x, y, z. If I have low trust in the model I may not want to make certain decisions.

Interviewer: Thank you for explaining. I might come back to a few topics later on. But I had some other questions I had in my head. And I'm going to speak a little about personal experience and having data as a tool to make decisions as well. Are based on other based on personal experience, gut feeling, or other based on data, roughly speaking, what's your thoughts there?

Participant: Probably a combination of the two. I think you can, you can be quite subjective about some things. For example, if there's been historic issues in a certain area, then you might think that actually. Well, with a certain person who you know, is less good at doing this particular thing like managing finances than you might think, actually, well, the data is no different from project A to project B, but I know that this person struggles with finances, this person doesn't. The same goes with the AI, but then it is the type of AI model or interpretability I think that affects my perception. Data is also important, you know, if you're looking at finances, again, if your forecast is way over your allocated budget, that's data, that you're then making a decision offering an intervention off. So yes, a combination of the two.

Interviewer: Would you say that you have enough data today to make the decisions that you do? Or do you feel that you're faced with some situations where you actually don't have enough data to make an informed decision?

Participant: I think you can always have more data on this. And yes, I would say that more data would help make better decisions as it stands at the moment from where we currently are, you could probably get to a point where you can get too much data, which overwhelms you. But as it stands from where we are, currently, I think, yes, more data would be would be valuable, and also a better way of capturing that data. So, having lots of data is great. But that doesn't do anything other than the raw loss of data. So, how do you interrogate that data? How do you analyze it? What are the outputs that you then are able to draw from that data? The data in itself is only you know, it's just a block of stuff stored somewhere. It's the insights that you get and how you generate those insights, which are all the important thing? I think.

Interviewer: So, please explain deeper how you interpret the AI output?

Participant: Well we are a team who is interpreting the output. I think if I understood how the system would come to a decision, then I'd probably feel quite comfortable. Yeah, as things stand at the moment, I would think that whatever the recommendation is generated is a recommendation. And it's always going to be offer given sets of data. And it's quite difficult to capture all the different variables there are when you're looking at how to make a decision. So, you know, for catching a finance perspective, and a milestone perspective, or whatever, that's great, you're coming up with a recommendation on that. But I know that there might be other

considerations in terms of business resource availability, or the strategic direction for the organization might be changing next month. And I and I know that this will be more of a priority than this, but it's not quite there. So, the data says, this is still the priority, but I know it's changing next month for that. So, the decision when this is made, will be something else. So that's a rather convoluted way of trying to make my point, but that nothing will replace the mind necessarily, when it is how you use the tool, isn't it. If you're using it to help you make a decision, as opposed to wanting it to make the decision for you. But it's then to me to cap or apply those factors as I see fit based on my knowledge experience skill set. Because at the end of the day, I'm accountable for the decision, not the tool, you know, you're not going to be they'll say, well, yeah, refer you to the black box, you can play that's not gonna, that's not gonna work with anyone, is it?

Interviewer: Thank you for expanding on this. How would you say your own experience affects this process?

Participant: Hmm my own experience in the AI model or the project experience?

Interviewer: Ah yes, the project experience and when you interpret the AI report.

Participant: Well my personal experience is always in play. I use my own experience as a reference tool box. Is it always correct, probably not, but I have a gut feeling based on something. But here I think the more data we have the more reliable the report will be and hopefully will be in line with my experience.

Interviewer: When you decide whether or not to act on the AI report, how can you justify you decision to either follow or go against the AI?

Participant: Well I try to be as objective and critical as possible. To not agree with anything or anyone just for the sake of it, but to rely on my personal experience. But I don't know if that's what you mean?

Interviewer: Well yes I think you can express freely, but also what do you rely on when you don't follow the AI report?

Participant: So we try to bring in as many different perspectives as possible. And we also do manual comparison with other situations and projects that we can learn from. But we make sure we follow our process and protocol when we do not do as the report suggests. Then we can make good choice, and mitigation actions that are effective.

Interviewer: Thank you for expanding on that. What would you say there are any other factors that you can highlight with affects whether you go forward with the AI report or decide not to following it?

Participant: Well I can say from experience that if the project methodology and plan is very fixed, that the sponsor or myself for that matter believe the project plan is the best of the best and nothing is wrong with it, it will be very difficult to just say let's follow the AI and let's change the plan. Specially if the data is not anchored with the sponsor or myself in this example.

Interviewer: Okay I see, is there anything that can mitigate this do you think?

Participant: I think it goes back to the understanding of the data, and the circumstances the project plan is based on as well as the on going data report.

Interviewer: Can you expand on this please?

Participant: In terms of data? Or different types? Because I, my simple answer would be, the later the later stages of the projects you're going to have captured the most data would be the logical answer to that. But I'm not sure if that's all to begin with. If there's like it, was there something else you're trying to get out of the question? I feel that's too simplistic and answer, like stating the obvious.

Interviewer: In which project phase the currently do you think data is most important?

Participant: I think there are two, they're probably thinking on my feet here, they're probably to two points. The first is the initial justification for investing resource in doing a project at the beginning. And I think so as, as I touched on before, I think that's always an area of weakness, because you need as much data as possible in order to give an informed decision as to whether or not to go ahead with the project. But that's the point in time where you know the least. So, you're estimating costs, you're estimating benefits. In a lo' of instances, you can't say for sure that we're goin' to save a million pounds, and it's going to cost 100,000. But ideally, you would like to be able to say exactly that. And then you know what you're where you stand. I think the second point is probably in a kind of in a waterfall environment. But I suppose from an a'Ile perspective, you could do it with MVP as well is before you go live with whatever you've built. So To make sure that the data is supporting the decision to flip the switch and launch the system so that customers users are actually using this thing in anger, you've got that's an important point where you need to be assessing your data to give you the answer as to whether or not you're in a position to say yes or no to launching would be my the two standout points for me as I think about it now.

Interviewer: Thank you. So, moving further on in the product lifecycle you begin to report and you begin to gather mor data. Is there any specific factors in the data process you believe is significant?

Participant: I think there's always room for improvement. I think there's reporting there as you've got to tailor it to the stakeholder as well to understand what the needs of the person that you're providing the information are. So, in that some reports is not just as straightforward as saying they kind of this is how much we're forecasting to cost, forecasting to spend. This is the actuals. And therefore, the variance is this, sometimes you've got to be a little bit more nuanced and subjective. So, you know, are you asking for decision? Are you asking for directions? So? Or are you trying to highlight something that you know, is of particular interest to this stakeholder group, which may be, I suppose, what I'm saying is probably less of a kind of statistical presentation, and more of a verbal kind of talk. Does that make sense?

Interviewer: Yeah, absolutely. Thank you. What about your perception of how unique projects are? Does this impact your decision process? How aware are you of "project uniqueness"?

Participant: Hmm interesting, I believe projects are unique in some sense, but have a lot in common too. Everything is not new. As long as the data is updated I think do change my perception through out the project and not hold onto things that happened before.

Interviewer: Do you believe that a perception of uniqueness can affect the trust and the decision to go with or against the AI report?

Participant: Also interesting, hmm, I think if someone believes their project is unique then they must operate in a very complex and unique project environment. And if that is so, I can see how they might have difficulty to believe the AI model has correct data and have less trust in the AI model to perform high quality analysis. It is crucial I have an AI analysis that is accurate and the performance is trustworthy [trust in AI model], otherwise I would not use it and it would be a waste of time to use the AI. And of course it's the reverse that if I trust the model is performing well, then I will use its analysis [willingness to take corrective action].

Interviewer: Okay thank you for sharing that. We are actually running out of time, is there anything you would like to add to our conversation?

Participant: Oh okay, no not really, hm its been very interesting. I hope you research goes well.

Interviewer: I appreciate your time and patience. Hope to stay in touch forward.

Participant: Thank you bye, yes thank you

Session 2 March 2022

Interviewer: Thank you for meeting me again. I have draw some feedback loops based on my collected data. I did send you this before hand I think. I'd like to show some specific causal links separately, and then I can demonstrate the full loops.

Participant: That's fine.

Interviewer: SO here I have a chain with overriding AI, when the scenario is that you don't agree with the AI analysis and it you decide to escalate the projects, a root cause of this is misaligned information here.

Participant: So is there a question there?

Interviewer: Oh sorry I would like to iteratively validate my research findings. Do you see this represents your decision process when you go against the AI and escalate the project?

Participant: I understand, let me have a look… I get stuck with this "misalignment of goals and objectives", I mean how is this? I feel that the AI is very often on point with its analysis, but I do also feel that I sometimes have the most relevant information based on a recent delay [project overruns] [misaligned goals and objectives] and can therefore take the decision to override the AI suggestion, is that what this means? Because I don't have trustworthy AI output, I get that.

Interviewer: Yes exactly, when there is for example a project update or something new that has happened which is not yet recorded by the AI model, that is when information asymmetry happens, meaning the model and you have different information essentially.

Participant: Oh I see, let me look more then. I follow the links here and I see the plus and minus signs. What are these?

Interviewer: Yes these are the influence, so here we see information asymmetry increasing misaligned goals. Would you say this model is representative to your decision process? (waiting a few minutes for the participant to read it all)

Participant: Yes I would say so, it goes then to escalation of commitment I see, trust increases this to not take action. Yes I would say so.

Session 2 December 2021

Session 3 May 2022

P21 September 2020

Interviewer: Okay, perfect. I'll just jump in where we ended. I want to ask you about your perception of AI and your experience of this technology?

Participant: I think generally, I mean, most people think and I think of it in terms of the scientific side of things, that you can somehow have something that's almost like a human brain that connects things, disparate activities, and then makes connections between them, and enables you to use that intelligence in some way, shape or form to improve how you do things. So it's essentially taking data and synthesize it and make each other judgments much more readily.

Interviewer: I understand, thank you. Have you been exposed to AI in your workplace?

Participant: We use more or less. Differently depending on the specific role I've had.

Interviewer: I understand, thank you. And if I if I say the term machine learning, does that, ring any bells? Are you familiar with this term in your work?

Participant: Again, again, all these things, right? Seem to me also does, seem to step towards the same thing, right? How do you make something more efficient, rather than end to end that doesn't need human intervention?

Interviewer: Perfect, thank you. So can you give me some background to your, to your current role and your previous experience within projects?

Participant: Yeah, so I mean, I've got a broad-based background of working primarily in financial services in either a systems management background, programming in the early days. And then I joined a company within the bank industry. And at that time, I started to manage projects, then managed project teams and programs. Then I saw the need for that particular team in Europe at the time, they didn't have a project management office. So, didn't have any structure around forecasting, planning for the resource planning. And so, kind of looked at build, looking at the frameworks around the industry, coming up with a framework we could use. Then I went to the States for about 10 years, and manage various different

Interviewer: So, based on your current role. How do tou use the AI and how does it assist your decision-making would you say?

Participant: Decisions. So, first, one of the things that are going to have to do is I would have 16 project managers, they all report to the AI system also for further analysis. So, we were trying to forecast when we might get work coming through and who we should assign to that work. So, the right mix, the right seniority, and something that's, you know, clearly a judgment you have to make at the time as to whether you pull somebody off of something that they currently working

on to work on something more important? Or do you just leave them where they are and put somebody else on there, will improve projects, it's judgments around funding? How how's the project going escalations to senior management, negotiations with suppliers around pricing and contracts? Helping project managers with making risky decisions. So that of that nature? Strategically, it's what's our, what's the maturity scale of our current organization? Do we need to train our project managers more in certain areas? What's the progression path for those people? And then where organizationally are we? And I think this is this last bit sort of changes, depending on the nature of the economics and, and the cycle of the organization. So right now, it could be that we're better off having a centralized project office, Project Management Office, rather than project managers being centralized, that flip and flops within organizations, depending on who's driving it, what's driving it, etc.

Interviewer: Interesting. Thank you. So yeah, that was very interesting to you. Thank you for clarifying. Is it assumable correct for me to assume that some of your projects do fail?

Participant: Yes, that's correct.

Interviewer: What areas would you say are the biggest reasons for why your projects do not succeed?

Participant: It's, I think it's a typical things of scope. So, the scope is not well understood. And therefore, the cost and time for it usually exceeds both a great deal of what the original expectations were. So, it fails on that level, and it also fails. And therefore, the expectations and the customer satisfaction around that. I think it fails here or routinely because of lack of skilled out or adequate number of resources. So, there's too much change, trying to be orchestrated at the same time, with limited amount of people that you can rely on to help execute that change.

Interviewer: Interesting. thank you. So, from your experience does the AI assist you in this?

Participant: I think it's the nature of the activity dictates the framework and the approach to that particular project. But in principle, generally, it's making the scope smaller and more manageable, quantifiable. It could be tactically, providing some sort of seed funding that says will we allow you to do this investigation and then based off the back of that, if you've got, because there's the cone of uncertainty around your estimates. So, as time goes on the AI gets better, obviously your estimation improves, as you know more about what you're going to be doing. So there's that component to it. I think it's we don't have currently have an entity Project Management Office view of the organization and what constraints they're under. So, what are the teams working on tracking the resourcing, and then therefore making judgments on whether something should actually take off or not, whether it should stay on the ground, to use airline terminology? Because why would you continue to plow more projects into that pipeline and

start them if you can't manage and contain the ones that are already up and fly. So, I think there's a component of that. And then there's the nature of the funding regime, which is its annual. So, as a regulator, we are not supposed to retain profit to a certain degree. So therefore, we are always looking

at the April to March timeframe, in terms of funding cycles, which becomes a limiting factor in people's minds around when they, if and when they can start things if and when things should be finished, etc., I'm always looking for anything that can give us a little bit of an edge. Okay, so I'm more intrigued than negative. Right. So not having seen any evidence, too much evidence of it, then I'd be more intrigued as to what you think there are areas for opportunity on, views things like you can use. You can use, I guess, algorithms to sort of figure out when hotspots could be for projects, try and deploy, based on the size, scale, complexity. I've done that before. With my teams. Yeah, so that's my view.

Interviewer: So, you've done that with the organisations you've been with and using algorithms?

Participant: . So previously I've been involved when we tried to use we actually patented, it was called the red zone. So, what we did was we took all of the releases that we knew about across the technical releases that we know, going on across the bank. And then we put together a scoring mechanism that said, What's the size scale? Which customers are being impacted, etc. When are these things occurring? The created sort of a graduated view of when things might be a problem could be potential collisions and things occurring. Again, use that to generate some release management discussions.

Interviewer: What other areas would you say automaton and AI can or should be used for?

Participant: Yeah, I mean, as I said earlier, it's really mainly PowerPoint, Excel, Word. So, we create business cases in Word we put them on SharePoint Online, we create an Excel forecasts and track issues and risks, we put those into individual project, Excel workbooks, we create PowerPoints to talk through our rack status is and whatnot. All of that therefore means that you've got all this unstructured data all over this all over the shop. The main drivers for that, I think, two-fold, right. So, when I joined to it a bit years ago, the pier, portfolio delivery organization was only about 18 months old. So, when they formed the group, they formed it by bringing somebody externally to run as program director. And then they hired in new hires. And they brought in some people internally create a group of 40 or 50 or so people, some people were BA, some people were testers, some people business change, there wasn't any project management delivery framework for them to follow. So like stage gates, are you familiar with all these terms. So, it wasn't any stage gating any of that in place, when I joined my predecessor, it

rolled out and recently rolled out this quality management framework. But hadn't stipulated the teams, when gating had to occur when updates have to occur weekly, monthly, whatever has no project portfolio management tool to which to manage it and to set out when things were going to be grandfathered, etc. So, I actually walked into a situation where there would have been an external audit. And there were loads of things on that quality management framework that the auditors thought we needed to fix. So, I spent my six months tenure in that group, both hiring project management resources, because they were, the team is half of what it should have been. And then fixing the audit items, because of COVID and other things, funding was just put on hold, we now need to look at is how do we develop that framework to be somewhat agnostic of Agile versus waterfall scalable? And then from a tool's perspective, how do we start to build intelligence into how we work, so we don't have all this manual manipulation reading.

Interviewer: Thank you for that, you mentioned before escalation to senior management, how is your perception of escalation?

Participant: Yeah, I think we only create stuff based on business cases, we don't, therefore stem the business cases through from a forecasting standpoint, maybe you some of the information to look at how accurate or inaccurate, we've been over time? And that's where escalation comes in I guess, through the AI analysis. And is there a pattern there? So are we how far off are we basically ever for things? And the tricky thing, as you're probably aware with projects are, by their very nature, every single one of them is, is different in size, and scale and activity so very difficult to get it right from the start. And the human factor has a huge influence right on decisions that be made wrong decisions wrong, going the wrong direction, etc. So, the more clinical around that, whether that is by using data, I think would help. Because I think sometimes there's, as we've seen in other things, there's a rush to judgment to do something. But if he stood back and looked at the data, maybe the data would have told you to go a different direction.

Interviewer: Do you see any resistance within your project team towards using, you mentioned a bit the reward and proof of concepts, but do you see a general resistance or general positivity against trying new technology within your project program team and in relation to escalation?

Participant: It's generally positive. Right. I mean, obviously. So, some people more attuned to doing

things and others. But no, I mean, I think from my standpoint, our department is probably one of the more on the front foot around trying to change how we do things change the culture. So yeah, I don't see any too much resistance in that.

Interviewer: So what makes you choose to follow the AI?

Participant: I don't think it's just the efficiency, is it? It's the quality. So, if you can prove that the quality increases in some way, shape or fashion by doing that, then absolutely. I mean, we're always looking for a little bit of extra time, right to, to focus on the customer, focus on what we're delivering, rather than the administration piece of it. So, low value work is something they're traditionally everyone wants to try and get rid of. If you look at it from a bank perspective, well, what the banking industry decided to do 10

– 15 years ago was say, well, with offshore or with offshore, that type of work, right? Unfortunately, then what happens is the offshore it, and then that becomes a premium service that people want, or service that people want, the premiums for, those companies start to go up, because there's a demand supply, demand curve, right. And then it becomes less beneficial to those companies to use offshore. So, then they started to go into Eastern Europe or into the Caribbean or wherever, right to try and find people. So yeah, I think that's Yeah.

Interviewer: What is your thoughts on the next step of your decision process and AI?

Participant: But if we were if we're gonna build something, then these a lot of maintenance, or needs a lot of thought about the inputs to make sure that the outputs come out correctly. We that's one of the biggest drawbacks, I think, with some of these tools that get sold to companies, is they're rich with gadgets and gimmicks and things that you they say you can do with them. Once you start to use them, you start to put them in practice, what you find is that excuse the phrase crappy and crap out. So, you end up with if you don't structure it properly, just a lot of licensing costs, but you get a great deal out of the back of it. We had a demo last week from a company. And you know, again, in principle, there's lots of things you can do with it. That's all, but it's what can you actually get out of that tool extract out that tool and use to your benefit. If you can't get it out provide it to like the chief operating officer. I was just on the phone with in a easily digestible format, then you're going to end up extracting that data back into those very same things like Excel that you were trying to avoid, to then put it back into something that can be presented back to them. What's the point of that?

Interviewer: Definitely, there's a lot of there's a lot of commercial motivations. Do you think that you have the infrastructure technical infrastructure to provide this data, actually, or improve it somehow would you need to start with a better infrastructure in that sense?

Participant: We don't really have a database or source for the project data at the moment to do more than what are doing. So you're really sort of starting from ground zero on that. You can take it from all the different unstructured sources like SharePoint and whatnot. But, then you want to look at how you want to capture that information. And hierarchically structure it, if it's by the

directorates that we have within the organization. So, information that is the social relationships, isn't it between who you're doing it for, what it's delivering, how much it's costing, etc. Where those variants of information need to be pulled out for different reporting purposes?

Interviewer: Yeah, it makes sense. So, I'm trying to, to build on that. Because in the end, it comes down to your project team and the team members how they want to use it. And they've said that interpretability, and why our model makes the decision is very important to them. What is your thoughts on explainability in AI models?

Participant: I think from my point of view, it is sometimes hard to trust the data source unless you can explain at least where, what the inputs are and therefore how it's how it's getting to the results, it gets to. Obviously, we put a lot of trust in all sorts of things, don't we, on a day to day basis. Some of these those fly the plane is trained and knows what they're doing, etc. But yeah, if we can see that something has been used before. And the result was, predicted results can be proven to show that they're consistent. And I think, you know, we'd be happy to use anything like that. But it's that sort of bit like the fact that you right? You want to see that somebody so be over looking at and it's got some, it's got too many side effects.

Interviewer: Thank you. I understand. Good comparison. And I'd like a few years ahead, where would you say that maybe your data processing capabilities have common maybe what kind of tools would you perhaps see you been using?

Participant: Yes, I think in the next few years, what we want to do is we want to be in a position where we're the aggregators globally and trying to help the executive committee make more timely and correct decisions around funding, prioritization, selection, etc. So, I think, annual planning, being involved in that more, and having more of a broader view of what's going on across the organization. At the moment, we're somewhat siloed, into the confines of what we've been asked to deliver. We have a very small budget profile, and we're not running some of the broader base programs. So, I think, from a PMO standpoint, it would be the prioritization selection. And we, I affectionately call it air traffic control. So, it's basically seeing everything that's up in the air and seeing things that are on the ground, making sure there aren't any collisions. That used to be again, that used to be a function I had prior company that we used to have. And then therefore, optimizing a lot more about when we make when we sequence and plan the work that we plan. And knowing that as we were talking about earlier, can we get better at our cost estimation, have forecasting etc. So that we can show some of those results. Right now, we don't really show a great deal of portfolio level data. And we don't run things in a more programmatic sense to have that view. So that's where I see the next few years that going really.

Interviewer: Interesting. I really appreciate you taking the time and I know you have a very busy schedule. So, I will I will leave you now. I will turn off the recording.

P22 January 2021

Interviewer: So yes, to begin with, the perception of AI is very broad. And I'd like to just ask aboutyour perception of this term, what's your experience of AI?

Participant: My perspective states there's some sort of machine learning and some sort of decision-making process that happens through data and a machine some description, that then outputs a result that then real humans would make take action upon, or an influence from. I think again, it depends on what you're talking about. It's everything from a chat bot to deep learning, I've used it in my personal life but at work we use the system to assist us. Something I'd actually considered was a possibility or a method to manage a project. So yeah, it's, I'm pretty new to this stuff.

Interviewer: It's also quite would be quite interesting to hear these other project managers, what kind of tool they use, because sometimes these tools are packaged as being AI. And for some people, and some comparative businesses for selling them the AI, it is Artificial Intelligence, while others would say, well, it's basically just a decision support to make it more efficient. Moving on, what's your current project role? And how long have you been in this room today?

Participant: Okay, so I've been with XX company for about a year and a half. And, and I've only worked on two projects since I started here. And the one that I'm on now, which has been the majority of the time that I've been here, is a regulation project. So, it's all about implementing new regulations, it's a change in in regulation that the X set out. And we are taking on these new regulations before the end of the year. So just before the Brexit transition.

Interviewer: Must be quite a difficult thing, then when the end of the Brexit will change something.

Participant: We basically have to write those regulations, so it's something that the UK wants to do. And it's pretty much happened now so is what we're taking on. It just means that after the 31st, we can have, we can tweak things and change things if we want to, whereas before we would have followed EU regulations. And so yeah, a bit more control.

Interviewer: Okay. Thank you for clarifying. So, is it assumable correct for me to say that not all of your projects deliver on time? And then some of them might fail on the way to deliver the objectives and some escalation happens?

Participant: Yeah, I think that, you know, generally, is just like you can say that that's something that project managers will come across is, you know, often things, won't deliver on time. And with the regulation projects like this one, it's not necessarily within your control whether something can deliver in time, because we're influenced by so many external parties and things like that. So, if they say, they're not going to do something until a certain point, there's nothing we can do about it. It's not that we can't, you know, it's not like a supplier where you could apply pressure or, you know, something, is it we just have to kind of move our goalposts. And for instance, when Coronavirus happened, the project went on hold for three months. So, it was actually meant to deliver in July this year, but now it's delivering basically now, right now, this week.

Interviewer: Yeah, I understand, it must be a lot of uncertainty as well. Can you expand on the controlling part?

Participant: Well we control and measure the progress of all tasks.

Interviewer: Thank you. So, I like to just go back to your previous project experience, have you had any previous experience before this project?

Participant: Yeah, so before this, I worked for a kind of web development company. They had hundreds of classified websites. And they were set up in a bit more of a kind of family run business, a lot smaller site, 300 people, you know, no rule defined process, we're trying to be agile and working with spreadsheets had an external development company in India, as well as various other development companies associated with them. So, it was kind of like, a lot more loose in terms of process. So, you could make change quicker, and you could get things done. But there was also high amount of stress and because you know, the goalposts are constantly changing and the director might decide they want a new thing. And that's it, you know, you're doing the new thing. So, it's very different worlds. And then before that I work for a track record global, which is the company that works with suppliers in China, to ensure that their products can enter the EU.

Interviewer: Interesting. So, based on that. And if I understood you correctly, today you have more structured processes that your previous organizations?

Participant: Yeah, certainly. I mean, I think, you know, there's, there's a definite balance, as everybody probably is aware that you can go too far in the other direction. And we do have a lot of paperwork. A lot of, you know, templates and data related things that need to be filled out for every project. And that is, I find that quite difficult. Which I'm sure was probably come out in some of the questions that were asked by last year in the first round from several people. We all have the same sort of use on some of the documentation that we have to complete that risk

management is quite just long winded. Yeah, it's a massive spreadsheet. And it's difficult to manage, but at the same time necessary for data purposes.

Interviewer: I understand. Okay, thank you for clarifying. So how is AI used today in your project?

Participant: I'd say resource availability. And, you know, we do have a bit of a, it's not necessarily clear who works on what, and how you booked that person. And, you know, to get that definite commitment to the time, and you know, because everyone's so busy, you may be able to pin them down for three days, but then if you know, anything else moves on the project, and you actually need them for four days, or you need them to start later or something, and that's tricky. So yeah, I say, resource management's quite a big piece. Funding, finance tracking. So, it's kind of an invisible piece. And actually, retrospectively look back on what they've done and see if it's the same, and then might track things that I don't, they might turn around and say, Oh, yeah, we don't count that we don't have to charge for that. And, you know, all that kind of things a little bit. Who's chargeable? Who isn't? That's that I've struggled personally with that a little bit. It's the clarity on it. Really as to what I should be tracking, what I shouldn't be tracking. And we do have someone within our department who is the kind of contact for that, and he works closely with finance. But I guess the main thing for me is, it's, I'd like to be in one place and be actually have the visibility of a pot of money, and you know, how you're spending it and things like that. And at the moment is sort of, you know, some stuff are done by email. And that's hard to kind of trace.

Interviewer: I understand. Thank you for clarifying. If you would like to increase project success, then would you focus on these areas to improve? Or would you focus on other areas in order to increase the success? What, what's your thoughts there?

Participant: And it's a big question, you know, I've only worked on two projects within a this place and both of them have very different. Yeah, I think resource management would be quite a key one, and roles and responsibility, and, you know, being able to have kind of an index of who where and what they do, and how you booked that person. And, yeah, and availability. Yeah, rather than spending lots of time on phone calls, negotiating with managers and trying to work out, you know, beg, borrow and steal somebody in a way that it feels like they're doing you a favor, rather than you know, this is your role. I need you to do it.

Interviewer: How about when the project escalate and the AI indicate control measures, is this an area for project success?

Participant: I'd said yes, it is how it is today but I'm open minded for it to increase, I'm intrigued to know how much data and what data you'd need to collect in order to, you know, be able to

come to some sort of guidance and direction. I've, you know, I've been trying to think about what we're talking what actually, you know, what it actually could do?

And yeah, I'm interested to know what the possibilities would be. So yeah, I said, I'm open minded.

Interviewer: So, do you see that maybe you have a role to identify areas where AI could be used? Or do you see it might be other hierarchical management level to take these decisions or actually?

Participant: I think it would be hierarchical management level, depending on you know, what you guys work out is your next steps. And if there needs to be more workshops at this sort of level, whereyou're talking about the framework we use and how we measure the activities that we go on about, thenthat

would probably be project management level and PMO level, but in terms of kind of, you know, making decisions about what could be done to help, then I think that that would be a higher level.

Interviewer: I understand. Thank you. So asking a bit more about data, is your organization discussing the area of how to improve data. You said before that you mentioned data previously, but do you say that there's a discussion right now of how to improve this process? Or what's your thoughts?

Participant: Data is such a massive subject. Everything in a spreadsheet, but they'll pull the information elsewhere in order to make a report. And they're relying on us getting that data correct for project management work. And that would probably be one of my skeptical kind of feelings of AI is, you know, it's only as good as the data that you put in. And if you imagine an older organization, that's a bit, you know, behind the times tech, and technically, imagine what that data is going to be like, if anything, probably clear a lot of it out. And yeah, obviously, data refers to so many different departments and areas, and it depends on Yeah, if it's just project management data, then that would be a lot easier to control. Sorry, I've kind of forgotten the question a little bit there where to start rambling about things.

Interviewer: Yeah, data is very broad term as well, like you said, but based on projects, decisions, and decisions, and the decisions you make, would you say they are more based on data project data? Or are they based on your project experience and gut feeling?

Participant: I mean, it isn't for informative. So, when they consider a policy, a senior policy person's view and opinion to be the data source is just not actually recorded in a spreadsheet or

a database. And then decisions are made off the back of that. So yeah, it says it more guts than informative, gut decisions, then, you know, data sources.

Interviewer: Thank you. So, based on I'm gonna ask a bit about project lifecycle as a Project Manager. You understood that you're following a project lifecycle in the organization?

Participant: I guess because the majority of the project happens post-business phase. And that's probably the answer. I don't know a lot about what happens pre-business phase. But I understand that obviously, you know, the moment, the best pitches that you can build an information that you can collect up front before you actually commit to doing a project, and certainly in other organizations, that was a big pain point. You know, it's a project before they've even, you know, really established the details. That was a big issue. And but both of the projects that I've had I've been handed the business case has been done. And the findings, you know, pretty much agreed. And so, you know, for me, that's, you know, that's where the all of the trouble that you might see on a project would begin. But if that business phase isn't done, correctly, with all the information, then it could be pre.

Interviewer: So let's say you will have an image scenario within, let's say, yeah, let's say the actual AI tool produces an analysis which opposes your gut feeling nad in your experience? What would be your reaction? And what would be your action?

Participant: I guess, if I was immediately in disagreements with it, then I probably resort back to that, oh, it's only as good as the data, where's this information come from? And does it know what it's talking about? All this, you know, doubting it, all that kind of stuff. And but if I trusted the data, and trusted the research, and has seen it proven and good examples, and it gave me an opinion that I disagreed with, I think that, you know, if we got to that comfort place, I think I could eventually get to seeing in the same way that you would see a colleague's opinion that you disagreed with, you kind of are a bit more rational about it, and you are able to consider that opinion. And think, okay, maybe I'm not looking at this in the right way. Maybe I need to think of it in that way. And then see that perspective, that point of view. But it would have to be like I say, all of that trust and proven technology. And in order to get to that place.

Interviewer: Sounds very interesting that you mentioned that you would treat it as some kind of input from a colleague then. But yeah, of course, for my understanding, you would need to trust the data.

Participant: Yeah. But that's quite a big ask. That's quite a lot. So, you know, I'd like to see examples of how it works and things like that before I was slightly less sceptical.

Interviewer: I understand. So, you mentioned that you could see the AI system, AI model as a colleague, then are you? Are you open to have a collaborative relationship to this AI tool?

Participant: I mean, depends how much it asks me to do. I mean, selfishly, I would want the machine to tell me, rather than me having to do like a lot to be able to help make these decisions. We almost want it to be kind of a silent observer that would then kind of highlight important information.

Interviewer: So I see the time is running out. So, how would you feel if you would have a tool based on language processing, like the Amazon Alexa understanding, voice recognition? So, this tool would then be able to be used in a meeting where these changes are recorded, and then automatically updated? How would you the reacting if you would have this kind of technology? Would you see as a possibility? Or would you be skeptical towards it?

Participant: I mean, all of these things, I think I immediately I'm kind of like, well, that's exciting. But at the same time, I'm like, I don't want to be recorded every single second of my life, which, you know, as we all know, now, working from home constantly, you are just sat at your computer talking to it. I mean, you know, how well that actually is transcribed, and not only transcribed, that translated into actions, which could, you know, change parameters of the project dates or delivery or milestones, or, you know, how actually would then, you know, change project, that's. I really need to trust that if someone wasn't moving my benchmarks without me kind of believing and, you know, confirming that I agree, you know, something said, you know, today, it sounds like you've lost your resource for this piece of work. And we found another one on the system for you. And do you want to accept that? Or? It sounds like you're, you've pushed out for a week, do you want us to update your project plan for you, and tell you what the impact is, you know, stuff like that, if it asked me to confirm things. That could be helpful. Providing, you know what, you know, it's like with, everyone's got so many apps on their phones, the constant kind of noise around us. And a lot of the time, your kind of didn't dismiss things. So, it needs to be very correct and helpful. Otherwise, it's just going to be another piece of noise. That’s really, really interesting. Yeah, kind of having a bit boring day. So that was really interesting.

Interviewer: I'm glad. I'm glad. So yeah, thank you very much.

List of References

ABDEL-HAMID, T. K. 2011. Single-Loop Project Controls: Reigning Paradigms or Straitjackets? *Project Management Journal,* 42**,** 17-30.

ABIODUN, O. I., JANTAN, A., OMOLARA, A. E., DADA, K. V., MOHAMED, N. A. & ARSHAD, H. 2018. State-of-the-art in artificial neural network applications: A survey. *Heliyon,* 4**,** e00938.

ACEBES, F., PAJARES, J., GALÁN, J. M. & LÓPEZ-PAREDES, A. 2014. A new approach for project control under uncertainty. Going back to the basics. *International Journal of Project Management,* 32**,** 423-434.

ACEBES, F., PEREDA, M., POZA, D., PAJARES, J. & GALÁN, J. M. 2015. Stochastic earned value analysis using Monte Carlo simulation and statistical learning techniques. *International Journal of Project Management,* 33**,** 1597-1609.

ACKERMANN, F. 2024. Managing Grand Challenges: Extending the Scope of Problem Structuring Methods and Behavioural Operational Research. *European Journal of Operational Research*.

AGARWAL, N. & RATHOD, U. 2006. Defining 'success' for software projects: An exploratory revelation. *International Journal of Project Management,* 24**,** 358-370.

AKINCI, C. & SADLER-SMITH, E. 2012. Intuition in management research: A historical review. *International Journal of Management Reviews,* 14**,** 104-122.

AL-SUBHI, S. H., PAPAGEORGIOU, E. I., PÉREZ, P. P., MAHDI, G. S. S. & ACUÑA, L. A. 2021. Triangular Neutrosophic Cognitive Map for Multistage Sequential Decision-Making Problems. *International Journal of Fuzzy Systems,* 23**,** 657-679.

ALABAS, C., ALTIPARMAK, F. & DENGIZ, B. 2002. A comparison of the performance of artificial intelligence techniques for optimizing the number of kanbans. *Journal of the Operational Research Society,* 53**,** 907-914.

ALADWANI, A. M. 2002. An Integrated Performance Model Information Systems Projects. *Journal of Management Information Systems,* 19**,** 185-210.

ALDERMAN, N., IVORY, C., MCLOUGHLIN, I. & VAUGHAN, R. 2005. Sense-making as a process within complex service-led projects. *International journal of project management,* 23**,** 380-385.

ALI, S., ABUHMED, T., EL-SAPPAGH, S., MUHAMMAD, K., ALONSO-MORAL, J. M., CONFALONIERI, R., GUIDOTTI, R., DEL SER, J., DÍAZ-RODRÍGUEZ, N. & HERRERA, F. 2023. Explainable Artificial Intelligence (XAI): What we know and what is left to attain Trustworthy Artificial Intelligence. *Information fusion,* 99**,** 101805.

ALJAŽ, T. 2024. Leveraging ChatGPT for Enhanced Logical Analysis in the Theory of Constraints Thinking Process. *Organizacija,* 57**,** 202-214.

AMÂNDIO, A. M., COELHO DAS NEVES, J. M. & PARENTE, M. 2021. Intelligent planning of road pavement rehabilitation processes through optimization systems. *Transportation Engineering,* 5.

APM 2019. The Golden Thread: A study of the contribution of project management and project to the UK's economy and society. (Accessed: 18 February 2020).

APM 2024. The Golden Thread: A Study of the Contribution of the Project Profession to the UK's Economy.

ARNOTT, D. & GAO, S. 2019. Behavioral economics for decision support systems researchers. *Decision Support Systems,* 122**,** 113063.

ARRIETA, A. B., DÍAZ-RODRÍGUEZ, N., DEL SER, J., BENNETOT, A., TABIK, S., BARBADO, A., GARCÍA, S., GIL-LÓPEZ, S., MOLINA, D. & BENJAMINS, R. 2020. Explainable Artificial Intelligence (XAI): Concepts, taxonomies, opportunities and challenges toward responsible AI. *Information Fusion,* 58**,** 82-115.

ASSWAD, J. & MARX GÓMEZ, J. 2021. Data ownership: a survey. *Information,* 12**,** 465.

ATANASIU, R. 2021. The lifecycle of heuristics as managerial proverbs. *Management Decision*.

BADEWI, A. 2016. The impact of project management (PM) and benefits management (BM) practices on project success: Towards developing a project benefits governance framework. *International journal of project management,* 34**,** 761-778.

BADIRU, A. B. & SIEGER, D. B. 1998. Neural network as a simulation metamodel in economic analysis of risky projects. *European Journal of Operational Research,* 105**,** 130-142.

BAESENS, B., MUES, C., MARTENS, D. & VANTHIENEN, J. 2009. 50 years of data mining and OR: upcoming trends and challenges. *Journal of the operational research society,* 60**,** S16-S23.

BAHI, A., GHARIB, J. & GAHI, Y. 2024. Integrating Generative AI for Advancing Agile Software Development and Mitigating Project Management Challenges. *International Journal of Advanced Computer Science and Applications,* 15**,** 54-61.

BAKSHI, T., SINHARAY, A., SARKAR, B. & SANYAL, S. K. 2016. Introduction to soft-set theoretic solution of project selection problem. *Benchmarking: An International Journal,* 23**,** 1643-1657.

BALDERAS, F., FERNÁNDEZ, E., CRUZ-REYES, L., GÓMEZ-SANTILLÁN, C. & RANGEL-VALDEZ, N. 2022. Solving group multi-objective optimization problems by optimizing consensus through multi-criteria ordinal classification. *European Journal of Operational Research,* 297**,** 1014-1029.

BARCAUI, A. & MONAT, A. 2023. Who is better in project planning?Generative artificial intelligence or project managers? *Project Leadership and Society,* 4**,** 100101.

BARREDO ARRIETA, A., DÍAZ-RODRÍGUEZ, N., DEL SER, J., BENNETOT, A., TABIK, S., BARBADO, A., GARCIA, S., GIL-LOPEZ, S., MOLINA, D., BENJAMINS, R., CHATILA, R. & HERRERA, F. 2020. Explainable Artificial Intelligence (XAI): Concepts, taxonomies, opportunities and challenges toward responsible AI. *Information Fusion,* 58**,** 82-115.

BATHALLATH, S., SMEDBERG, Å. & KJELLIN, H. 2016. Managing project interdependencies in IT/IS project portfolios: a review of managerial issues. *International journal of information systems and project management,* 4**,** 67-82.

BATSELIER, J. & VANHOUCKE, M. 2015. Construction and evaluation framework for a real-life project database. *International Journal of Project Management,* 33**,** 697-710.

BECKER, K. H. 2016. An outlook on behavioural OR–Three tasks, three pitfalls, one definition. *European Journal of Operational Research,* 249**,** 806-815.

BELL, D. E., RAIFFA, H. & TVERSKY, A. 1988. *Decision making: Descriptive, normative, and prescriptive interactions*, cambridge university Press.

BENBYA, H., DAVENPORT, T. H. & PACHIDI, S. 2020. Artificial intelligence in organizations: Current state and future opportunities. *MIS Quarterly Executive,* 19.

BENDOLY, E., CROSON, R., GONCALVES, P. & SCHULTZ, K. 2010. Bodies of knowledge for research in behavioral operations. *Production and Operations Management,* 19**,** 434-452.

BENGTSON, A., HAVILA, V. & ÅBERG, S. 2018. Beyond project closure: Why some business relationships recur in subsequent projects. *Project Management Journal,* 49**,** 89-104.

BENSCHOP, N., HILHORST, C. A., NUIJTEN, A. L. & KEIL, M. 2020a. Detection of early warning signals for overruns in IS projects: linguistic analysis of business case language. *European Journal of Information Systems,* 29**,** 190-202.

BENSCHOP, N., HILHORST, C. A. R., NUIJTEN, A. L. P. & KEIL, M. 2020b. Detection of early warning signals for overruns in IS projects: linguistic analysis of business case language. *European Journal of Information Systems,* 29**,** 190-202.

BERENTE, N., SALGE, C. A. D. L., MALLAMPALLI, V. K. P. & PARK, K. 2022. Rethinking Project Escalation: An Institutional Perspective on the Persistence of Failing Large-Scale Information System Projects. *Journal of Management Information Systems,* 39**,** 640-672.

BETTEMIR, Ö. H. & SONMEZ, R. 2015. Hybrid genetic algorithm with simulated annealing for resource-constrained project scheduling. *Journal of Management in Engineering,* 31**,** 04014082.

BIEDENBACH, T. & JACOBSSON, M. 2016. The Open Secret of Values: The Roles of Values and Axiology in Project Research. *Project Management Journal,* 47**,** 139-155.

BILGIN, G., DIKMEN, I., BIRGONUL, M. T. & OZORHON, B. 2023. A Decision Support System for Project Portfolio Management in Construction Companies. *International Journal of Information Technology and Decision Making,* 22**,** 705-735.

BINGHAM, C. B. & EISENHARDT, K. M. 2011. Rational heuristics: the 'simple rules' that strategists learn from process experience. *Strategic management journal,* 32**,** 1437-1464.

BINGHAM, C. B. & EISENHARDT, K. M. 2014. Response to Vuori and Vuori's commentary on "Heuristics in the strategy context". *Strategic Management Journal,* 35**,** 1698-1702.

BISHOP, C. M. 1995. *Neural networks for pattern recognition*, Oxford university press.

BLACK, J. S. & VAN ESCH, P. 2020. AI-enabled recruiting: What is it and how should a manager use it? *Business Horizons,* 63**,** 215-226.

BLAZEWICZ, J., LENSTRA, J. K. & KAN, A. R. 1983. Scheduling subject to resource constraints: classification and complexity. *Discrete applied mathematics,* 5**,** 11-24.

BONACCORSI, A., APREDA, R. & FANTONI, G. 2020. Expert biases in technology foresight. Why they are a problem and how to mitigate them. *Technological Forecasting and Social Change,* 151**,** 119855.

BOŻEJKO, W., HEJDUCKI, Z. & WODECKI, M. 2012. Applying metaheuristic strategies in construction projects management. *Journal of Civil Engineering and Management,* 18**,** 621-630.

BOZORGZADEH, A. & UMAR, T. 2023. Automated progress measurement using computer vision technology in UK construction. *Proceedings of the Institution of Civil Engineers: Smart Infrastructure and Construction,* 176**,** 165-182.

BREIT, L. A. & VOLKMANN, C. K. 2024. Recent developments in entrepreneurial marketing: systematic literature review, thematic analysis and research agenda. *Journal of Research in Marketing and Entrepreneurship,* 26**,** 228-256.

BRIGHTON, H. & GIGERENZER, G. 2012. Homo heuristicus and the bias–variance dilemma. *Action, perception and the brain*. Springer.

BROCKNER, J. 1992. The escalation of commitment to a failing course of action: Toward theoretical progress. *Academy of management review,* 17**,** 39-61.

BRYDE, D., UNTERHITZENBERGER, C. & JOBY, R. 2018. Conditions of success for earned value analysis in projects. *International Journal of Project Management,* 36**,** 474-484.

BUBECK, S., CHANDRASEKARAN, V., ELDAN, R., GEHRKE, J., HORVITZ, E., KAMAR, E., LEE, P., LEE, Y. T., LI, Y. & LUNDBERG, S. 2023. Sparks of artificial general intelligence: Early experiments with gpt-4. *arXiv preprint arXiv:2303.12712*.

BUEHLER, R., MESSERVEY, D. & GRIFFIN, D. 2005. Collaborative planning and prediction: Does group discussion affect optimistic biases in time estimation? *Organizational Behavior and Human Decision Processes,* 97**,** 47-63.

BURKE, R. 2013a. *Project management: planning and control techniques*, John Wiley & Sons.

BURKE, R. 2013b. Project management: planning and control techniques. *New Jersey, USA,* 26.

BURTON, J. W., STEIN, M. K. & JENSEN, T. B. 2020. A systematic review of algorithm aversion in augmented decision making. *Journal of behavioral decision making,* 33**,** 220-239.

BUXTON, M. & RIVERS, R. 2014. Escalation of Commitment: The Effects of Magnitude of Loss, Monitoring and the Presence of an Alternative Investment. Can a Project 90% Complete be Stopped? *Journal of Accounting and Finance,* 14**,** 72.

CABIDDU, F., MOI, L., PATRIOTTA, G. & ALLEN, D. G. 2022. Why do users trust algorithms? A review and conceptualization of initial trust and trust over time. *European Management Journal,* 40**,** 685-706.

CANCER, V., TOMINC, P. & ROZMAN, M. 2023. Multi-Criteria Measurement of AI Support to Project Management. *IEEE Access,* 11**,** 142816-142828.

CANTARELLI, C. C. 2025. Kahneman's Legacy in Project Management: Improving Decision-Making and Performance. *International Journal of Project Management***,** 102697.

CAO, G., DUAN, Y., EDWARDS, J. S. & DWIVEDI, Y. K. 2021. Understanding managers' attitudes and behavioral intentions towards using artificial intelligence for organizational decision-making. *Technovation,* 106**,** 102312.

CHANG, Y. & LIANG, Y. 2023. Intelligent Risk Assessment of Ecological Agriculture Projects from a Vision of Low Carbon. *Sustainability (Switzerland),* 15.

CHAPHALKAR, N. B., IYER, K. C. & PATIL, S. K. 2015. Prediction of outcome of construction dispute claims using multilayer perceptron neural network model. *International Journal of Project Management,* 33**,** 1827-1835.

CHARMAZ, K. 2006. *Constructing grounded theory: A practical guide through qualitative analysis,* London, Sage.

CHARMAZ, K. 2008. Reconstructing grounded theory. *The SAGE handbook of social research methods***,** 461-478.

CHAUDHARY, S., DHIR, A., FERRARIS, A. & BERTOLDI, B. 2021. Trust and reputation in family businesses: A systematic literature review of past achievements and future promises. *Journal of Business Research,* 137**,** 143-161.

CHECKLAND, P. 2000. Soft systems methodology: a thirty year retrospective. *Systems research and behavioral science,* 17**,** S11-S58.

CHEN, Q. Q. & PARK, H. J. 2021. How anthropomorphism affects trust in intelligent personal assistants. *Industrial Management & Data Systems,* 121**,** 2722-2737.

CHEN, S.-M., GRIFFIS, F. H., CHEN, P.-H. & CHANG, L.-M. 2012. Simulation and analytical techniques for construction resource planning and scheduling. *Automation in Construction,* 21**,** 99-113.

CHEN, Y., AHIAGA-DAGBUI, D. D., THAHEEM, M. J. & SHRESTHA, A. 2023. Toward a deeper understanding of optimism bias and transport project cost overrun. *Project Management Journal,* 54**,** 561-578.

CHENG, CAO, M. T. & HERIANTO, J. G. 2020. Symbiotic organisms search-optimized deep learning technique for mapping construction cash flow considering complexity of project. *Chaos, Solitons and Fractals,* 138.

CHENG, HOANG, N. D. & WU, Y. W. 2015. Cash flow prediction for construction project using a novel adaptive time-dependent least squares support vector machine inference model. *Journal of Civil Engineering and Management,* 21**,** 679-688.

CHENG & ROY, A. F. V. 2011. Evolutionary fuzzy decision model for cash flow prediction using time-dependent support vector machines. *International Journal of Project Management,* 29**,** 56-65.

CHENG, TSAI, H. C. & HSIEH, W. S. 2009a. Web-based conceptual cost estimates for construction projects using Evolutionary Fuzzy Neural Inference Model. *Automation in Construction,* 18**,** 164-172.

CHENG, TSAI, H. C. & LIU, C. L. 2009b. Artificial intelligence approaches to achieve strategic control over project cash flows. *Automation in Construction,* 18**,** 386-393.

CHENG, M.-Y., TSAI, H.-C. & LIU, C.-L. 2009c. Artificial intelligence approaches to achieve strategic control over project cash flows. *Automation in Construction,* 18**,** 386-393.

CHEVALLIER, N. & RUSSELL, A. D. 1998. Automated schedule generation. *Canadian Journal of Civil Engineering,* 25**,** 1059-1077.

CHIH, Y.-Y. & ZWIKAEL, O. 2015. Project benefit management: A conceptual framework of target benefit formulation. *International Journal of Project Management,* 33**,** 352-362.

CHIPULU, M., OJIAKO, U., GARDINER, P., WILLIAMS, T., MOTA, C., MAGUIRE, S., SHOU, Y., STAMATI, T. & MARSHALL, A. 2014. Exploring the impact of cultural values on project performance. *International Journal of Operations & Production Management,* 34**,** 364-389.

CHIPULU, M., OJIAKO, U., MARSHALL, A., WILLIAMS, T., BITITCI, U., MOTA, C., SHOU, Y., THOMAS, A., DIRANI, A. E., MAGUIRE, S. & STAMATI, T. 2019. A dimensional analysis of stakeholder assessment of project outcomes. *Production Planning & Control,* 30**,** 1072-1090.

CHOI, S.-W., LEE, E.-B. & KIM, J.-H. 2021. The engineering machine-learning automation platform (emap): a big-data-driven ai tool for contractors' sustainable management solutions for plant projects. *Sustainability,* 13**,** 10384.

CHONG, V. K. & SURYAWATI, R. F. 2010. De-escalation strategy: The impact of monitoring control on managers' project evaluation decisions. *Journal of Applied Management Accounting Research,* 8**,** 39.

CHOU, J. S., CHENG, M. Y., WU, Y. W. & PHAM, A. D. 2014. Optimizing parameters of support vector machine using fast messy genetic algorithm for dispute classification. *Expert Systems with Applications,* 41**,** 3955-3964.

CHOU, J. S., LIN, C. W., PHAM, A. D. & SHAO, J. Y. 2015. Optimized artificial intelligence models for predicting project award price. *Automation in Construction,* 54**,** 106-115.

CHOUNG, H., DAVID, P. & ROSS, A. 2023. Trust in AI and its role in the acceptance of AI technologies. *International Journal of Human–Computer Interaction,* 39**,** 1727-1739.

CHUNG, N. C., CHUNG, H., LEE, H., BROCKI, L., CHUNG, H. & DYER, G. 2024. False Sense of Security in Explainable Artificial Intelligence (XAI). *arXiv preprint arXiv:2405.03820*.

CICMIL, S. 2006. Understanding project management practice through interpretative and critical research perspectives. *Project management journal,* 37**,** 27-37.

COELHO, J. & VANHOUCKE, M. 2020. Going to the core of hard resource-constrained project scheduling instances. *Computers & Operations Research,* 121**,** 104976.

COMPEN, B., PITTHAN, F., SCHELFHOUT, W. & DE WITTE, K. 2022. How to elicit and cease herding behaviour? On the effectiveness of a warning message as a debiasing decision support system. *Decision support systems,* 152**,** 113652.

COOPER 1993a. The rework cycle: why projects are mismanaged. *PM network,* 7**,** 5-7.

COOPER, K. G. The rework cycle: benchmarks for the project manager. 1993b. Project Management Institute.

CUBRIC, M. 2020. Drivers, barriers and social considerations for AI adoption in business and management: A tertiary study. *Technology in Society,* 62.

CUELLAR, M. J., KEIL, M. & JOHNSON, R. D. 2006. The deaf effect response to bad news reporting in information systems projects. *e-Service Journal,* 5**,** 75-97.

CURRIE, K. & DRABBLE, B. 1992. Knowledge-based planning systems: a tour. *International Journal of Project Management,* 10**,** 131-136.

DANIEL, P. A. & DANIEL, C. 2018. Complexity, uncertainty and mental models: From a paradigm of regulation to a paradigm of emergence in project management. *International Journal of Project Management,* 36**,** 184-197.

DARKO, A., GLUSHAKOVA, I., BOATENG, E. B. & CHAN, A. P. C. 2023. Using Machine Learning to Improve Cost and Duration Prediction Accuracy in Green Building Projects. *Journal of Construction Engineering and Management,* 149.

DAVENPORT, T. H. & RONANKI, R. 2018. Artificial intelligence for the real world. *Harvard Business Review*.

DE BOCK, K. W., COUSSEMENT, K., CAIGNY, A. D., SŁOWIŃSKI, R., BAESENS, B., BOUTE, R. N., CHOI, T.-M., DELEN, D., KRAUS, M., LESSMANN, S., MALDONADO, S., MARTENS, D., ÓSKARSDÓTTIR, M., VAIRETTI, C., VERBEKE, W. & WEBER, R. 2024. Explainable AI for Operational Research: A defining framework, methods, applications, and a research agenda. *European Journal of Operational Research,* 317**,** 249-272.

DE BRITO DUARTE, R., CORREIA, F., ARRIAGA, P. & PAIVA, A. 2023. AI Trust: Can Explainable AI Enhance Warranted Trust? *Human Behavior and Emerging Technologies,* 2023**,** 4637678.

DE WIT, A. 1988. Measurement of project success. *International Journal of Project Management,* 6**,** 164-170.

DELISE, L. A., LEE, B. & CHOI, Y. 2023. Understanding project management performance using a comparative overrun measure. *International Journal of Project Management,* 41**,** 102450.

DEMEULEMEESTER, E. L. & HERROELEN, W. S. 2006. *Project scheduling: a research handbook*, Springer Science & Business Media.

DENICOL, J., DAVIES, A. & KRYSTALLIS, I. 2020. What Are the Causes and Cures of Poor Megaproject Performance? A Systematic Literature Review and Research Agenda. *Project Management Journal,* 51**,** 328-345.

DENNIS, A. R., LAKHIWAL, A. & SACHDEVA, A. 2023. AI Agents as Team Members: Effects on Satisfaction, Conflict, Trustworthiness, and Willingness to Work With. *Journal of Management Information Systems,* 40**,** 307-337.

DENYER, D. & TRANFIELD, D. 2009. Producing a systematic review.

DESMOND, C. 2017. Project management tools-software tools. *IEEE Engineering Management Review,* 45**,** 24-25.

DIETZ, T. & BURNS, T. R. 1992. Human agency and the evolutionary dynamics of culture. *Acta Sociologica,* 35**,** 187-200.

DOSHI-VELEZ, F. & KIM, B. 2018. Considerations for evaluation and generalization in interpretable machine learning. *Explainable and interpretable models in computer vision and machine learning*. Springer.

DOU, F., YE, J., YUAN, G., LU, Q., NIU, W., SUN, H., GUAN, L., LU, G., MAI, G. & LIU, N. 2023. Towards artificial general intelligence (agi) in the internet of things (iot): Opportunities and challenges. *arXiv preprint arXiv:2309.07438*.

DOUKIDIS, G. I. & PAUL, R. J. 1990. A survey of the application of artificial intelligence techniques within the OR society. *Journal of the Operational Research Society,* 41**,** 363-375.

DOUMPOS, M., ZOPOUNIDIS, C., GOUNOPOULOS, D., PLATANAKIS, E. & ZHANG, W. 2023. Operational research and artificial intelligence methods in banking. *European Journal of Operational Research,* 306**,** 1-16.

DREYFUS, H. L. 1972. What computers can't do: The limits of artificial intelligence.

DRUMMOND, H. 1995. De-escalation in decision making: A case of a disastrous partnership. *Journal of Management Studies,* 32**,** 265-281.

DRUMMOND, H. 2014. Escalation of commitment: When to stay the course? *Academy of Management Perspectives,* 28**,** 430-446.

DUAN, Y., EDWARDS, J. S. & DWIVEDI, Y. K. 2019. Artificial intelligence for decision making in the era of Big Data–evolution, challenges and research agenda. *International Journal of Information Management,* 48**,** 63-71.

DWIVEDI, R., DAVE, D., NAIK, H., SINGHAL, S., OMER, R., PATEL, P., QIAN, B., WEN, Z., SHAH, T. & MORGAN, G. 2023. Explainable AI (XAI): Core ideas, techniques, and solutions. *ACM Computing Surveys,* 55**,** 1-33.

DWIVEDI, Y. K., HUGHES, L., ISMAGILOVA, E., AARTS, G., COOMBS, C., CRICK, T., DUAN, Y., DWIVEDI, R., EDWARDS, J., EIRUG, A., GALANOS, V., ILAVARASAN, P. V., JANSSEN, M., JONES, P., KAR, A. K., KIZGIN, H., KRONEMANN, B., LAL, B., LUCINI, B., MEDAGLIA, R., LE MEUNIER-FITZHUGH, K., LE MEUNIER-FITZHUGH, L. C., MISRA, S., MOGAJI, E., SHARMA, S. K., SINGH, J. B., RAGHAVAN, V., RAMAN, R., RANA, N. P., SAMOTHRAKIS, S., SPENCER, J., TAMILMANI, K., TUBADJI, A., WALTON, P. & WILLIAMS, M. D. 2019. Artificial Intelligence (AI): Multidisciplinary perspectives on emerging challenges, opportunities, and agenda for research, practice and policy. *International Journal of Information Management,* (In Press)**,** 101994.

DWIVEDI, Y. K., HUGHES, L., ISMAGILOVA, E., AARTS, G., COOMBS, C., CRICK, T., DUAN, Y., DWIVEDI, R., EDWARDS, J., EIRUG, A., GALANOS, V., ILAVARASAN, P. V., JANSSEN, M., JONES, P., KAR, A. K., KIZGIN, H., KRONEMANN, B., LAL, B., LUCINI, B., MEDAGLIA, R., LE MEUNIER-FITZHUGH, K., LE MEUNIER-FITZHUGH, L. C., MISRA, S., MOGAJI, E., SHARMA, S. K., SINGH, J. B., RAGHAVAN, V., RAMAN, R., RANA, N. P., SAMOTHRAKIS, S., SPENCER, J., TAMILMANI, K., TUBADJI, A., WALTON, P. & WILLIAMS, M. D. 2021. Artificial Intelligence (AI): Multidisciplinary perspectives on emerging challenges, opportunities, and agenda for research, practice and policy. *International Journal of Information Management,* 57**,** 101994.

EDWARDS, W. 1961. Behavioral decision theory. *Annual review of psychology,* 12**,** 473-498.

EGHBALI-ZARCH, M., TAVAKKOLI-MOGHADDAM, R., DEHGHAN-SANEJ, K. & KABOLI, A. 2022. Prioritizing the effective strategies for construction and demolition waste management using fuzzy IDOCRIW and WASPAS methods. *Engineering, Construction and Architectural Management,* 29**,** 1109-1138.

EINHORN, H. J. & HOGARTH, R. M. 1981. Behavioral decision theory: Processes of judgment and choice. *Journal of Accounting Research***,** 1-31.

ENHOLM, I. M., PAPAGIANNIDIS, E., MIKALEF, P. & KROGSTIE, J. 2022. Artificial intelligence and business value: A literature review. *Information Systems Frontiers,* 24**,** 1709-1734.

FAEZY RAZI, F. & HOOMAN SHARIAT, S. 2017. A hybrid grey based artificial neural network and C&R tree for project portfolio selection. *Benchmarking: An International Journal,* 24**,** 651-665.

FANG, Y. & NG, S. T. 2019. Genetic algorithm for determining the construction logistics of precast components. *Engineering, Construction and Architectural Management,* 26**,** 2289-2306.

FARQUHAR, P. H. 1984. State of the art—utility assessment methods. *Management science,* 30**,** 1283-1300.

FARROW, E. 2021. Extending the Participant's Voice to Guide Artificial Intelligence Transformation Using Futures Methodology and Layered User Story Analysis. *World Futures Review,* 13**,** 214-236.

FEHER, K., VICSEK, L. & DEUZE, M. 2024. Modeling AI Trust for 2050: perspectives from media and info-communication experts. *AI & SOCIETY***,** 1-14.

FELDMAN, G. & WONG, K. F. E. 2018. When action-inaction framing leads to higher escalation of commitment: A new inaction-effect perspective on the sunk-cost fallacy. *Psychological science,* 29**,** 537-548.

FELICETTI, A. M., CIMINO, A., MAZZOLENI, A. & AMMIRATO, S. 2024. Artificial intelligence and project management: An empirical investigation on the appropriation of generative Chatbots by project managers. *Journal of Innovation & Knowledge,* 9**,** 100545.

FETHI, M. D. & PASIOURAS, F. 2010. Assessing bank efficiency and performance with operational research and artificial intelligence techniques: A survey. *European Journal of Operational Research,* 204**,** 189-198.

FLYVBJERG, B. 2007. Policy and planning for large-infrastructure projects: problems, causes, cures. *Environment and Planning B: planning and design,* 34**,** 578-597.

FLYVBJERG, B. 2008. Curbing optimism bias and strategic misrepresentation in planning: Reference class forecasting in practice. *European planning studies,* 16**,** 3-21.

FLYVBJERG, B. 2013. Quality control and due diligence in project management: Getting decisions right by taking the outside view. *International Journal of Project Management,* 31**,** 760-774.

FLYVBJERG, B. 2021. Top Ten Behavioral Biases in Project Management: An Overview. *Project Management Journal,* 52**,** 531-546.

FLYVBJERG, B. 2022. Heuristics for masterbuilders: Fast and frugal ways to become a better project leader. *Available at SSRN 4159984*.

FLYVBJERG, B., BUDZIER, A., CHRISTODOULOU, M. & ZOTTOLI 2024. *Uniqueness Bias: Why It Matters, How to Curb It*.

FLYVBJERG, B., BUDZIER, A., LEE, J. S., KEIL, M., LUNN, D. & BESTER, D. W. 2022. The Empirical Reality of IT Project Cost Overruns: Discovering A Power-Law Distribution. *Journal of Management Information Systems,* 39**,** 607-639.

FLYVBJERG, B., HOLM, M. S. & BUHL, S. 2002. Underestimating costs in public works projects - Error or lie? *Journal of the American Planning Association,* 68**,** 279-295.

FOBIRI, G., MUSONDA, I. & MULEYA, F. 2022. Reality capture in Construction Project Management: A review of opportunities and challenges. *Buildings,* 12**,** 1381.

FORD, D. N. & LYNEIS, J. M. 2020. System Dynamics Applied to Project Management: A Survey, Assessment, and Directions for Future Research. *System Dynamics: Theory and Applications***,** 285-314.

FORD, D. N., LYNEIS, J. M. & TAYLOR, T. Project controls to minimize cost and schedule overruns: A model, research agenda, and initial results. 2007 International System Dynamics Conference, 2007. Citeseer, 1-27.

FORD, D. N. & STERMAN, J. D. 2003. Overcoming the 90% syndrome: Iteration management in concurrent development projects. *Concurrent Engineering,* 11**,** 177-186.

FRANCO, L. A., HÄMÄLÄINEN, R. P., ROUWETTE, E. A. J. A. & LEPPÄNEN, I. 2021. Taking stock of behavioural OR: A review of behavioural studies with an intervention focus. *European Journal of Operational Research,* 293**,** 401-418.

FRANTZ, R. 2003. Herbert Simon. Artificial intelligence as a framework for understanding intuition. *Journal of Economic Psychology,* 24**,** 265-277.

FRIDGEIRSSON, T. V., INGASON, H. T., JONASSON, H. I. & GUNNARSDOTTIR, H. 2023. A Qualitative Study on Artificial Intelligence and Its Impact on the Project Schedule, Cost and Risk Management Knowledge Areas as Presented in PMBOK®. *Applied Sciences (Switzerland),* 13.

FRIDGEIRSSON, T. V., INGASON, H. T., JONASSON, H. I. & JONSDOTTIR, H. 2021. An authoritative study on the near future effect of artificial intelligence on project management knowledge areas. *Sustainability (Switzerland)*.

GARCIA, J. A. L., PENA, A. B., PEREZ, P. Y. P. & PEREZ, R. B. 2017. Project Control and Computational Intelligence: Trends and Challenges. *International Journal of Computational Intelligence Systems,* 10**,** 320-335.

GEMINO, A., REICH, B. H. & SAUER, C. 2007. A Temporal Model of Information Technology Project Performance. *Journal of Management Information Systems,* 24**,** 9-44.

GEORGANTA, E. & ULFERT, A.-S. 2024. My colleague is an AI! Trust differences between AI and human teammates. *Team Performance Management: An International Journal,* 30**,** 23-37.

GERALDI, J., MAYLOR, H. & WILLIAMS, T. 2011. Now, let's make it really complex (complicated). *International Journal of Operations & Production Management,* 31**,** 966-990.

GHOSH, B., DAUGHERTY, P. R., WILSON, J. & BURDEN, A. 2019. Taking a systems approach to AI. Harvard Business Review.

GIGERENZER, G. 2004. Fast and frugal heuristics: The tools of bounded rationality. *Blackwell handbook of judgment and decision making,* 62**,** 88.

GIGERENZER, G., CZERLINSKI, J. & MARTIGNON, L. 1999. How good are fast and frugal heuristics? *Decision science and technology: Reflections on the contributions of Ward Edwards*. Springer.

GIGERENZER, G. & GAISSMAIER, W. 2011. Heuristic decision making. *Annual review of psychology,* 62**,** 451-482.

GIGERENZER, G. & GOLDSTEIN, D. G. 1996. Reasoning the fast and frugal way: models of bounded rationality. *Psychological review,* 103**,** 650.

GIGERENZER, G., REB, J. & LUAN, S. 2022. Smart heuristics for individuals, teams, and organizations. *Annual Review of Organizational Psychology and Organizational Behavior,* 9**,** 171-198.

GIGERENZER, G. & SELTEN, R. 2001. Rethinking rationality. *Bounded rationality: The adaptive toolbox,* 1**,** 12.

GIGERENZER, G. & STURM, T. 2012. How (far) can rationality be naturalized? *Synthese,* 187**,** 243-268.

GIGERENZER, G. & TODD, P. M. 1999. Fast and frugal heuristics: The adaptive toolbox. *Simple heuristics that make us smart*. Oxford University Press.

GIOIA, D. A., CORLEY, K. G. & HAMILTON, A. L. 2012. Seeking qualitative rigor in inductive research: Notes on the Gioia methodology. *Organizational research methods,* 16**,** 15-31.

GKINKO, L. & ELBANNA, A. 2023. Designing trust: The formation of employees' trust in conversational AI in the digital workplace. *Journal of Business Research,* 158**,** 113707.

GLASER, B. & STRAUSS, A. 1967. The discovery of grounded theory. 1967. *Weidenfield & Nicolson, London***,** 1-19.

GLASER, B. G. & STRAUSS, A. L. 2017. *Discovery of grounded theory: Strategies for qualitative research*, Routledge.

GLIKSON, E. & WOOLLEY, A. W. 2020. Human trust in artificial intelligence: Review of empirical research. *Academy of Management Annals,* 14**,** 627-660.

GOERTZEL, B. 2014. Artificial general intelligence: concept, state of the art, and future prospects. *Journal of Artificial General Intelligence,* 5**,** 1.

GOLDKUHL, G. 2012. Pragmatism vs interpretivism in qualitative information systems research. *European journal of information systems,* 21**,** 135-146.

GONZÁLEZ-CARRASCO, I., COLOMO-PALACIOS, R., LÓPEZ-CUADRADO, J. L. & PEÑALVO, F. J. G. 2012. SEffEst: Effort estimation in software projects using fuzzy logic and neural networks. *International Journal of Computational Intelligence Systems,* 5**,** 679-699.

GOODWIN, T. 2018. *Digital Darwinism: Survival of the fittest in the age of business disruption*, Kogan Page.

GREESHMA, A. S. & EDAYADIYIL, J. B. 2022. Automated progress monitoring of construction projects using Machine learning and image processing approach. *Materials Today: Proceedings*.

GROESSER, S. N. & SCHAFFERNICHT, M. 2012. Mental models of dynamic systems: taking stock and looking ahead. *System dynamics review,* 28**,** 46-68.

GUEST, G., BUNCE, A. & JOHNSON, L. 2006. How many interviews are enough? An experiment with data saturation and variability. *Field methods,* 18**,** 59-82.

GUNNING, D. & AHA, D. 2019. DARPA's explainable artificial intelligence (XAI) program. *AI Magazine,* 40**,** 44-58.

GUO, K. & ZHANG, L. 2022. Multi-objective optimization for improved project management: Current status and future directions. *Automation in Construction,* 139**,** 104256.

GUPTA, S., MODGIL, S., BHATTACHARYYA, S. & BOSE, I. 2021. Artificial intelligence for decision support systems in the field of operations research: review and future scope of research. *Annals of Operations Research***,** 1-60.

GUPTA, S., MODGIL, S., BHATTACHARYYA, S. & BOSE, I. 2022. Artificial intelligence for decision support systems in the field of operations research: review and future scope of research. *Annals of Operations Research,* 308**,** 215-274.

GUPTA, S. K., GUNASEKARAN, A., ANTONY, J., GUPTA, S., BAG, S. & ROUBAUD, D. 2019. Systematic literature review of project failures: Current trends and scope for future research. *Computers & Industrial Engineering,* 127**,** 274-285.

HAENLEIN, M. & KAPLAN, A. 2019. A brief history of artificial intelligence: On the past, present, and future of artificial intelligence. *California management review,* 61**,** 5-14.

HAIR, J. F., CELSI, M., MONEY, A. H., SAMOUEL, P. & PAGE, M. J. 2016. *Essentials of business research methods,* New York, Routhledge.

HAJI-KAZEMI, S., ANDERSEN, B. & KLAKEGG, O. J. 2015. Barriers against effective responses to early warning signs in projects. *International Journal of Project Management,* 33**,** 1068-1083.

HAJIALI, M., MOSAVI, M. R. & SHAHANAGHI, K. 2020. A new decision support system at estimation of project completion time considering the combination of artificial intelligence methods based on earn value management framework. *International Journal of Industrial Engineering : Theory Applications and Practice,* 27**,** 1-12.

HÄMÄLÄINEN, R. P., LUOMA, J. & SAARINEN, E. 2013. On the importance of behavioral operational research: The case of understanding and communicating about dynamic systems. *European Journal of Operational Research,* 228**,** 623-634.

HARRISON, R., FISCHER, S., WALPOLA, R. L., CHAUHAN, A., BABALOLA, T., MEARS, S. & LE-DAO, H. 2021. Where do models for change management, improvement and implementation

meet? A systematic review of the applications of change management models in healthcare. *Journal of healthcare leadership*, 85-108.

HARTMANN & BRISKORN, D. 2022. An updated survey of variants and extensions of the resource-constrained project scheduling problem. *European Journal of Operational Research,* 297, 1-14.

HARTMANN, S. & BRISKORN, D. 2010. A survey of variants and extensions of the resource-constrained project scheduling problem. *European Journal of Operational Research,* 207, 1-14.

HASSIJA, V., CHAMOLA, V., MAHAPATRA, A., SINGAL, A., GOEL, D., HUANG, K., SCARDAPANE, S., SPINELLI, I., MAHMUD, M. & HUSSAIN, A. 2024. Interpreting black-box models: a review on explainable artificial intelligence. *Cognitive Computation,* 16, 45-74.

HAVILA, V., MEDLIN, C. J. & SALMI, A. 2013. Project-ending competence in premature project closures. *International Journal of Project Management,* 31, 90-99.

HAZıR, Ö. 2015. A review of analytical models, approaches and decision support tools in project monitoring and control. *International Journal of Project Management,* 33, 808-815.

HE, X. & MITTAL, V. 2007. The effect of decision risk and project stage on escalation of commitment. *Organizational Behavior and Human Decision Processes,* 103, 225-237.

HEAGNEY, J. 2016. *Fundamentals of project management*, Amacom.

HEATH, H. & COWLEY, S. 2004. Developing a grounded theory approach: a comparison of Glaser and Strauss. *International journal of nursing studies,* 41, 141-150.

HECHT-NIELSEN, R. 1992. Theory of the backpropagation neural network. *Neural networks for perception*. Elsevier.

HEINTZ, T. J. 1991. An object-oriented approach to planning and managing software development projects. *Information & management,* 20, 281-293.

HENDRY, L. 1987. The potential impact of artificial intelligence on the practice of OR. *European journal of operational research,* 28, 218-225.

HENNINK, M. M., HUTTER, I. & BAILEY, A. 2020. *Qualitative research methods,* Los Angeles, Sage.

HERMANN, E. & PUNTONI, S. 2024. Artificial intelligence and consumer behavior: From predictive to generative AI. *Journal of Business Research,* 180, 114720.

HERROELEN, W. 2005. Project scheduling—Theory and practice. *Production and operations management,* 14, 413-432.

HERROELEN, W. & LEUS, R. 2005. Project scheduling under uncertainty: Survey and research potentials. *European journal of operational research,* 165, 289-306.

HICKEY, G. 1997. The use of literature in grounded theory. *NT Research,* 2, 371-378.

HIRMAN, M., BENESOVA, A., STEINER, F. & TUPA, J. 2019. Project Management during the Industry 4.0 Implementation with Risk Factor Analysis. *Procedia Manufacturing,* 38, 1181-1188.

HOFF, K. A. & BASHIR, M. 2015. Trust in automation: Integrating empirical evidence on factors that influence trust. *Human factors,* 57, 407-434.

HOFFMAN, R. R., MUELLER, S. T., KLEIN, G. & LITMAN, J. 2018. Metrics for explainable AI: Challenges and prospects. *arXiv preprint arXiv:1812.04608*.

HOFMANN, P., JÖHNK, J., PROTSCHKY, D. & URBACH, N. Developing purposeful AI use cases–a structured method and its application in project management. 15th International Conference on Wirtschaftsinformatik (WI), Potsdam, Germany, 2020.

HOLLAND, J. H. 1992. Genetic algorithms. *Scientific american,* 267**,** 66-73.

HOLZMANN, V., ZITTER, D. & PESHKESS, S. 2022. The Expectations of Project Managers from Artificial Intelligence: A Delphi Study. *Project Management Journal*.

HOWARD-PAYNE, L. 2016. Glaser or Strauss? Considerations for selecting a grounded theory study. *South African Journal of Psychology,* 46**,** 50-62.

HSU, M., DACRE, N. & SENYO, P. K. 2021. Identifying Inter-Project Relationships with Recurrent Neural Networks: Towards an AI Framework of Project Success Prediction. *British Academy of Management*.

HUANG, M.-H. & RUST, R. T. 2018. Artificial intelligence in service. *Journal of Service Research,* 21**,** 155-172.

HUMMEL, P., BRAUN, M. & DABROCK, P. 2021. Own data? Ethical reflections on data ownership. *Philosophy & Technology,* 34**,** 545-572.

IDOGAWA, J., BIZARRIAS, F. S. & CÂMARA, R. 2023. Critical success factors for change management in business process management. *Business Process Management Journal,* 29**,** 2009-2033.

IKA, L. A. & PINTO, J. K. 2022. The "re-meaning" of project success: Updating and recalibrating for a modern project management. *International Journal of Project Management,* 40**,** 835-848.

ISRAEL, M. & HAY, I. 2006. *Research ethics for social scientists*, Sage.

JALILI, Y. & FORD, D. N. 2016. Quantifying the impacts of rework, schedule pressure, and ripple effect loops on project schedule performance. *System Dynamics Review,* 32**,** 82-96.

JARRAHI, M. H., ASKAY, D., ESHRAGHI, A. & SMITH, P. 2023. Artificial intelligence and knowledge management: A partnership between human and AI. *Business Horizons,* 66**,** 87-99.

JAUHAR, S. K., PRIYADARSHINI, S., PRATAP, S. & PAUL, S. K. 2023. A literature review on applications of Industry 4.0 in Project Management. *Operations Management Research,* 16**,** 1858-1885.

JENSEN, M. C. & MECKLING, W. H. 1976. Theory of the firm: Managerial behavior, agency costs and ownership structure. *Journal of financial economics,* 3**,** 305-360.

JOHNSON, M. P., MIDGLEY, G. & CHICHIRAU, G. 2018. Emerging trends and new frontiers in community operational research. *European Journal of Operational Research,* 268**,** 1178-1191.

JONES, B. D. 1999. Bounded rationality. *Annual review of political science,* 2**,** 297-321.

JUAREZ CORNELIO, J. R., SAINATI, T. & LOCATELLI, G. 2021. What does it take to kill a megaproject? The reverse escalation of commitment. *International Journal of Project Management,* 39**,** 774-787.

JÜNGEN, F. J. & KOWALCZYK, W. 1995. An intelligent interactive project management support system. *European Journal of Operational Research,* 84**,** 60-81.

KAHNEMAN, D. 1994. New challenges to the rationality assumption. *Journal of Institutional and Theoretical Economics (JITE)/Zeitschrift für die gesamte Staatswissenschaft*, 18-36.

KAHNEMAN, D. & LOVALLO, D. 1993. Timid choices and bold forecasts: A cognitive perspective on risk taking. *Management science,* 39, 17-31.

KAHNEMAN, D., LOVALLO, D. & SIBONY, O. 2011. Before you make that big decision. *Harvard business review,* 89, 50-60.

KAHNEMAN, D. & TVERSKY, A. 1979. Prospect theory: An analysis of decisions under risk. *Econometrica,* 47, 278.

KAHNEMAN, D. & TVERSKY, A. 2013. Prospect theory: An analysis of decision under risk. *Handbook of the fundamentals of financial decision making: Part I*. World Scientific.

KAMMOUH, O., KOK, M. W. A., NOGAL, M., BINNEKAMP, R. & WOLFERT, A. R. M. 2022. MitC: Open-source software for construction project control and delay mitigation. *SoftwareX,* 18, 101023.

KANAKARIS, N., KARACAPILIDIS, N., KOURNETAS, G. & LAZANAS, A. Combining Machine Learning and Operations Research Methods to Advance the Project Management Practice. International Conference on Operations Research and Enterprise Systems, 2019. Springer, 135-155.

KAPLAN, A. & HAENLEIN, M. 2019. Siri, Siri, in my hand: Who's the fairest in the land? On the interpretations, illustrations, and implications of artificial intelligence. *Business Horizons,* 62, 15-25.

KAPOOR, K., ZIAEE BIGDELI, A., DWIVEDI, Y. K., SCHROEDER, A., BELTAGUI, A. & BAINES, T. 2021. A socio-technical view of platform ecosystems: Systematic review and research agenda. *Journal of Business Research,* 128, 94-108.

KAPUR, P., PHAM, H., CHANDA, U. & KUMAR, V. 2013. Optimal allocation of testing effort during testing and debugging phases: a control theoretic approach. *International Journal of Systems Science,* 44, 1639-1650.

KARNOUSKOS, S. 2024. The Relevance of Large Language Models for Project Management. *IEEE Open Journal of the Industrial Electronics Society*, 1-11.

KASHIWAGI, D. T. & BYFIELD, R. 2002. Testing of minimization of subjectivity in best value procurement by using artificial intelligence systems in state of Utah procurement. *Journal of Construction Engineering and Management,* 128, 496-502.

KATSIKOPOULOS, K. V. 2014. Bounded rationality: the two cultures. *Journal of Economic Methodology,* 21, 361-374.

KAUFMANN, C. & KOCK, A. 2023. The performance effects of optimistic and pessimistic project status reporting behavior. *International Journal of Project Management,* 41, 102514.

KEIL, M., DEPLEDGE, G. & RAI, A. 2007. Escalation: The role of problem recognition and cognitive bias. *Decision Sciences,* 38, 391-421.

KEIL, M. & MÄHRING, M. 2010. Is your project turning into a black hole? *California Management Review,* 53, 6-31.

KEIL, M., MANN, J. & RAI, A. 2000. Why software projects escalate: An empirical analysis and test of four theoretical models. *Mis Quarterly*, 631-664.

KEIL, M. & ROBEY, D. 1999. Turning around troubled software projects: An exploratory study of the deescalation of commitment to failing courses of action. *Journal of Management Information Systems,* 15**,** 63-87.

KEIL, M. & ROBEY, D. 2001. Blowing the whistle on troubled software projects. *Communications of the ACM,* 44**,** 87-93.

KELLER, N. & KATSIKOPOULOS, K. V. 2016. On the role of psychological heuristics in operational research; and a demonstration in military stability operations. *European Journal of Operational Research,* 249**,** 1063-1073.

KELLY, S., KAYE, S.-A. & OVIEDO-TRESPALACIOS, O. 2023. What factors contribute to the acceptance of artificial intelligence? A systematic review. *Telematics and Informatics,* 77**,** 101925.

KERZNER, H. 2017. *Project management: a systems approach to planning, scheduling, and controlling*, John Wiley & Sons.

KERZNER, H. 2022. *Project management case studies*, John Wiley & Sons.

KHATUN, M. T., HIEKATA, K., TAKAHASHI, Y. & OKADA, I. 2023. Design and management of software development projects under rework uncertainty: a study using system dynamics. *Journal of decision systems,* 32**,** 265-288.

KIANI, A. 2024a. Artificial intelligence in entrepreneurial project management: a review, framework and research agenda. *International Journal of Managing Projects in Business*.

KIANI, A. 2024b. Artificial intelligence in entrepreneurial project management: a review, framework and research agenda. *International Journal of Managing Projects in Business,* ahead-of-print.

KILLEN, C. P., GERALDI, J. & KOCK, A. 2020. The role of decision makers' use of visualizations in project portfolio decision making. *International Journal of Project Management,* 38**,** 267-277.

KIM, H. & JANG, H. 2023. Predicting research projects' output using machine learning for tailored projects management. *Asian Journal of Technology Innovation*.

KLAPKA, J. 1994. Contemporary state of mathematical modelling in project management. *Modelling, Measurement and Control D,* 9**,** 43-63.

KLIR, G. & YUAN, B. 1995. *Fuzzy sets and fuzzy logic*, Prentice hall New Jersey.

KO, C.-H. & CHENG, M.-Y. 2007. Dynamic prediction of project success using artificial intelligence. *Journal of construction engineering and management,* 133**,** 316-324.

KOBBACY, K. A. & VADERA, S. 2011. A survey of AI in operations management from 2005 to 2009. *Journal of Manufacturing Technology Management*.

KOBBACY, K. A., VADERA, S. & RASMY, M. H. 2007. AI and OR in management of operations: history and trends. *Journal of the Operational Research Society,* 58**,** 10-28.

KOCKUM, F. & DACRE, N. 2021. Project Management Volume, Velocity, Variety: A Big Data Dynamics Approach. *Advanced Project Management,* 21.

KOLBJØRNSRUD, V., AMICO, R. & THOMAS, R. J. 2016. How artificial intelligence will redefine management. *Harvard Business Review,* 2.

KOPAINSKY, B. & LUNA-REYES, L. F. 2008. Closing the loop: promoting synergies with other theory building approaches to improve system dynamics practice. *Systems Research and Behavioral Science: The Official Journal of the International Federation for Systems Research,* 25**,** 471-486.

KORDZADEH, N. & GHASEMAGHAEI, M. 2022. Algorithmic bias: review, synthesis, and future research directions. *European Journal of Information Systems,* 31**,** 388-409.

KORHONEN, T., JÄÄSKELÄINEN, A., LAINE, T. & SAUKKONEN, N. 2023. How performance measurement can support achieving success in project-based operations. *International Journal of Project Management,* 41**,** 102429.

KOTZIAN, P. 2025. Decision-making modes and decision-making biases: improving decisions in escalation of commitment situations by triggering considerations? *International Journal of Economics and Business Research,* 29**,** 113-136.

KU, G. 2008. Learning to de-escalate: The effects of regret in escalation of commitment. *Organizational behavior and human decision processes,* 105**,** 221-232.

KUMAR, V., PANDEY, A. & SINGH, R. 2021. Can Artificial Intelligence be a Critical Success Factor of Construction Projects? Practitioner perspectives. *Technology Innovation Management Review,* 11.

KUMARASWAMY, M. M., NG, S. T., UGWU, O. O., PALANEESWARAN, E. & RAHMAN, M. M. 2004. Empowering collaborative decisions in complex construction project scenarios. *Engineering, Construction and Architectural Management,* 11**,** 133-142.

KUNC, M. System dynamics: a behavioral modeling method. 2016 Winter Simulation Conference (WSC), 2016. IEEE, 53-64.

KUNC, M. System dynamics: a soft and hard approach to modelling. 2017 2017a. IEEE, 597-606.

KUNC, M. System dynamics: A soft and hard approach to modelling. 2017 Winter Simulation Conference (WSC), 2017b. IEEE, 597-606.

KUNC, M. & KATSIKOPOULOS, K. V. 2022. Behavioural OR: Recent developments and future perspectives. *The Palgrave Handbook of Operations Research***,** 721-733.

KUNC, M., MALPASS, J. & WHITE, L. 2016. *Behavioral operational research: Theory, methodology and practice*, Springer.

KWAK, Y. H. & INGALL, L. 2007. Exploring Monte Carlo simulation applications for project management. *Risk management,* 9**,** 44-57.

LACERDA, R., ENSSLIN, L. & ROLIM ENSSLIN, S. 2011. A performance measurement view of IT project management. *International Journal of Productivity and Performance Management,* 60**,** 132-151.

LAENGLE, S., MERIGÓ, J. M., MIRANDA, J., SŁOWIŃSKI, R., BOMZE, I., BORGONOVO, E., DYSON, R. G., OLIVEIRA, J. F. & TEUNTER, R. 2017. Forty years of the European Journal of Operational Research: A bibliometric overview. *European Journal of Operational Research,* 262**,** 803-816.

LANGER, M., OSTER, D., SPEITH, T., HERMANNS, H., KÄSTNER, L., SCHMIDT, E., SESING, A. & BAUM, K. 2021. What do we want from Explainable Artificial Intelligence (XAI)? – A stakeholder perspective on XAI and a conceptual model guiding interdisciplinary XAI research. *Artificial Intelligence,* 296**,** 103473.

LAPPI, T., KARVONEN, T., LWAKATARE, L. E., AALTONEN, K. & KUVAJA, P. 2018. Toward an Improved Understanding of Agile Project Governance: A Systematic Literature Review. *Project Management Journal,* 49**,** 39-63.

LAWANI, A., FLIN, R., OJO-ADEDOKUN, R. F. & BENTON, P. 2023. Naturalistic decision making and decision drivers in the front end of complex projects. *International Journal of Project Management,* 41**,** 102502.

LEE, H. K., LEE, J. S. & KEIL, M. 2018. Using Perspective-Taking to De-escalate Launch Date Commitment for Products with Known Software Defects. *Journal of Management Information Systems,* 35**,** 1251-1276.

LEE, I. & SHIN, Y. J. 2020. Machine learning for enterprises: Applications, algorithm selection, and challenges. *Business Horizons,* 63**,** 157-170.

LEE, J. S., KEIL, M. & KASI, V. 2012. The Effect of an Initial Budget and Schedule Goal on Software Project Escalation. *Journal of Management Information Systems,* 29**,** 53-78.

LEE, J. S., KEIL, M. & WONG, K. F. E. 2021. When a growth mindset can backfire and cause escalation of commitment to a troubled information technology project. *Information Systems Journal,* 31**,** 7-32.

LEE, M. K. & RICH, K. Who is included in human perceptions of AI?: Trust and perceived fairness around healthcare AI and cultural mistrust. Proceedings of the 2021 CHI conference on human factors in computing systems, 2021. 1-14.

LEFLEY, F. 2006. Can a project champion bias project selection and, if so, how can we avoid it? *Management Research News*.

LENFLE, S. 2011. The strategy of parallel approaches in projects with unforeseeable uncertainty: The Manhattan case in retrospect. *International Journal of Project Management,* 29**,** 359-373.

LEVITT, R. E. & KUNZ, J. C. 1987. Using artificial intelligence techniques to support project management. *AI EDAM,* 1**,** 3-24.

LI, H., TANG, S. & LOVE, P. E. D. 2002. VHBuild. com: a Web-based system for managing knowledge in projects. *Internet Research*.

LI, W., DUAN, P. & SU, J. 2021. The effectiveness of project management construction with data mining and blockchain consensus. *Journal of Ambient Intelligence and Humanized Computing***,** 1-10.

LIPKE, W., ZWIKAEL, O., HENDERSON, K. & ANBARI, F. 2009. Prediction of project outcome: The application of statistical methods to earned value management and earned schedule performance indexes. *International Journal of Project Management,* 27**,** 400-407.

LIU, J., LIU, J., GAO, R., GAO, H. O. & LI, Y. 2019. Identifying project factors that affect an investor's escalation of commitment in public-private partnership projects. *Project Management Journal,* 50**,** 686-698.

LIU, Q., LIU, M., WANG, F. & XIAO, W. 2022. A dynamic stochastic search algorithm for high-dimensional optimization problems and its application to feature selection. *Knowledge-Based Systems,* 244**,** 108517.

LIU, S. & HAO, W. 2021. Forecasting the scheduling issues in engineering project management: Applications of deep learning models. *Future Generation Computer Systems,* 123**,** 85-93.

LIU, X., KANE, G. & BAMBROO, M. 2006. An intelligent early warning system for software quality improvement and project management. *Journal of Systems and Software,* 79**,** 1552-1564.

LIU, Y., LI, Y., SONG, K. & CHU, F. 2024. The two faces of Artificial Intelligence (AI): Analyzing how AI usage shapes employee behaviors in the hospitality industry. *International Journal of Hospitality Management,* 122**,** 103875.

LOCH, C. H. 2017. Creativity and risk taking aren't rational: Behavioral operations in MOT. *Production and Operations Management,* 26**,** 591-604.

LOCK, M. D. 2014. *The essentials of project management*, Ashgate Publishing, Ltd.

LOCKE, K. D. 2000. *Grounded theory in management research*, Sage.

LOOCK, M. & HINNEN, G. 2015. Heuristics in organizations: A review and a research agenda. *Journal of Business Research,* 68**,** 2027-2036.

LOUREIRO, S. M. C., GUERREIRO, J. & TUSSYADIAH, I. 2021. Artificial intelligence in business: State of the art and future research agenda. *Journal of Business Research,* 129**,** 911-926.

LOVALLO, D. & KAHNEMAN, D. 2003. Delusions of success. *Harvard business review,* 81**,** 56-63.

LOVE, P., HOLT, G. D., SHEN, L. Y., LI, H. & IRANI, Z. 2002. Using systems dynamics to better understand change and rework in construction project management systems. *International Journal of Project Management,* 20**,** 425-436.

LOVE, P., MATTHEWS, J. & IKA, L. A. 2023. Fast-and-frugal heuristics: an exploration into building an adaptive toolbox to assess the uncertainty of rework. *Production Planning & Control***,** 1-16.

LUNA-REYES, L. F. & ANDERSEN, D. L. 2003. Collecting and analyzing qualitative data for system dynamics: methods and models. *System Dynamics Review: The Journal of the System Dynamics Society,* 19**,** 271-296.

LUNG, L. W. & WANG, Y. R. 2023. Applying Deep Learning and Single Shot Detection in Construction Site Image Recognition. *Buildings,* 13.

LUOMA, J. 2016. Model-based organizational decision making: A behavioral lens. *European Journal of Operational Research,* 249**,** 816-826.

LYNEIS, J. M. & FORD, D. N. 2007. System dynamics applied to project management: a survey, assessment, and directions for future research. *System Dynamics Review: The Journal of the System Dynamics Society,* 23**,** 157-189.

MA, X., YANG, J., SUN, H., HU, Z. & WEI, L. 2021. Feature information prediction algorithm for dynamic multi-objective optimization problems. *European Journal of Operational Research,* 295**,** 965-981.

MAHANEY, R. C. & LEDERER, A. L. 2010. The role of monitoring and shirking in information systems project management. *International Journal of Project Management,* 28**,** 14-25.

MAHBOOBA, B., TIMILSINA, M., SAHAL, R. & SERRANO, M. 2021. Explainable Artificial Intelligence (XAI) to Enhance Trust Management in Intrusion Detection Systems Using Decision Tree Model. *Complexity,* 2021**,** 6634811.

MAKARIUS, E. E., MUKHERJEE, D., FOX, J. D. & FOX, A. K. 2020. Rising with the machines: A sociotechnical framework for bringing artificial intelligence into the organization. *Journal of Business Research,* 120**,** 262-273.

MANN, J. E. C. 1996. *The role of project escalation in explaining runaway information systems development projects: A field study*, Georgia State University.

MARTENS, A. & VANHOUCKE, M. 2017. A buffer control method for top-down project control. *European Journal of Operational Research,* 262**,** 274-286.

MARTENS, N. & ORZEN, H. 2021. Escalating commitment to a failing course of action — A re-examination. *European Economic Review,* 137**,** 103811.

MARTÍNEZ-ROJAS, M., MARÍN, N. & VILA, M. A. 2016. The role of information technologies to address data handling in construction project management. *Journal of Computing in Civil Engineering,* 30**,** 04015064.

MARTÍNEZ, D. M. & FERNÁNDEZ-RODRÍGUEZ, J. C. 2015. Artificial Intelligence applied to project success: a literature review. *IJIMAI,* 3**,** 77-84.

MARUGÁN, A. P. & GARCÍA MÁRQUEZ, F. P. 2017. Chapter 1 - Introduction. *In:* MARUGÁN, A. P. & GARCÍA MÁRQUEZ, F. P. (eds.) *Decision-Making Management*. Academic Press.

MASLEJ, N., FATTORINI, L., BRYNJOLFSSON, E., ETCHEMENDY, J., LIGETT, K., LYONS, T., MANYIKA, J., NGO, H., NIEBLES, J. C. & PARLI, V. 2023. Artificial intelligence index report 2023. *arXiv preprint arXiv:2310.03715*.

MASON, M. Sample size and saturation in PhD studies using qualitative interviews. Forum: Qualitative Social Research, 2010.

MASTROGIACOMO, S., MISSONIER, S. & BONAZZI, R. 2014. Talk Before It's Too Late: Reconsidering the Role of Conversation in Information Systems Project Management. *Journal of Management Information Systems,* 31**,** 47-78.

MCCLORY, S., READ, M. & LABIB, A. 2017. Conceptualising the lessons-learned process in project management: Towards a triple-loop learning framework. *International Journal of Project Management,* 35**,** 1322-1335.

MCCRAY, G. E., PURVIS, R. L. & MCCRAY, C. G. 2002. Project management under uncertainty: The impact of heuristics and biases. *Project Management Journal,* 33**,** 49-57.

MCLEAN, S., READ, G. J., THOMPSON, J., BABER, C., STANTON, N. A. & SALMON, P. M. 2023. The risks associated with Artificial General Intelligence: A systematic review. *Journal of Experimental & Theoretical Artificial Intelligence,* 35**,** 649-663.

MEREDITH & ZWIKAEL 2019. When is a Project Successful? *IEEE Engineering Management Review,* 47**,** 127-134.

MERRIAM, S. B. & TISDELL, E. J. 2015. *Qualitative research: A guide to design and implementation*, John Wiley & Sons.

MEYER, W. G. 2014. The effect of optimism bias on the decision to terminate failing projects. *Project Management Journal,* 45**,** 7-20.

MILLER, T. 2019. Explanation in artificial intelligence: Insights from the social sciences. *Artificial Intelligence,* 267**,** 1-38.

MINGERS, J. & WHITE, L. 2010. A review of the recent contribution of systems thinking to operational research and management science. *European Journal of Operational Research,* 207**,** 1147-1161.

MIR, F. A. & PINNINGTON, A. H. 2014. Exploring the value of project management: Linking Project Management Performance and Project Success. *International Journal of Project Management,* 32**,** 202-217.

MIRANI, R. & LEDERER, A. L. 1998. An instrument for assessing the organizational benefits of IS projects. *Decision Sciences,* 29**,** 803-838.

MISHRA, A., TRIPATHI, A. & KHAZANCHI, D. 2023. A Proposal for Research on the Application of AI/ML in ITPM: Intelligent Project Management. *International Journal of Information Technology Project Management,* 14.

MONTEALEGRE, R. & KEIL, M. 2000. De-escalating information technology projects: Lessons from the Denver International Airport. *Mis Quarterly***,** 417-447.

MONTOYA-TORRES, J. R., GUTIERREZ-FRANCO, E. & PIRACHICÁN-MAYORGA, C. 2010. Project scheduling with limited resources using a genetic algorithm. *International Journal of Project Management,* 28**,** 619-628.

MORECROFT, J. 2004. Mental models and learning in system dynamics practice.

MORRIS, P. W. G. 1989. Initiating major projects: the unperceived role of project management. *International Journal of Project Management,* 7**,** 180-185.

MORSE, J. M. 2010. Sampling in grounded theory.

MOUSAVI, S. & GIGERENZER, G. 2014. Risk, uncertainty, and heuristics. *Journal of Business Research,* 67**,** 1671-1678.

MUELLER, L., ALBRECHT, G., TOUTAOUI, J., BENLIAN, A. & CRAM, W. A. 2024. Navigating role identity tensions — IT project managers' identity work in agile information systems development. *European Journal of Information Systems***,** 1-24.

MÜLLER, R., LOCATELLI, G., HOLZMANN, V., NILSSON, M. & SAGAY, T. 2024. Artificial Intelligence and Project Management: Empirical Overview, State of the Art, and Guidelines for Future Research. *Project Management Journal*.

MUNNS, A. K. & BJEIRMI, B. F. 1996. The role of project management in achieving project success. *International Journal of Project Management,* 14**,** 81-87.

MUSCA, G. N., MELLET, C., SIMONI, G., SITRI, F. & DE VOGÜÉ, S. 2014. "Drop your boat!": The discursive co-construction of project renewal. The case of the Darwin mountaineering expedition in Patagonia. *International Journal of Project Management,* 32**,** 1157-1169.

MYERS, M. D. 2020. Qualitative research in business and management. Third edition ed. Los Angeles: SAGE.

NAENI, L. M., SHADROKH, S. & SALEHIPOUR, A. 2011. A fuzzy approach for the earned value management. *International Journal of Project Management,* 29**,** 764-772.

NATARAJAN, A. 2022. Reference Class Forecasting and Machine Learning for Improved Offshore Oil and Gas Megaproject Planning: Methods and Application. *Project Management Journal***,** 87569728211045889.

NENNI, M. E., DE FELICE, F., DE LUCA, C. & FORCINA, A. 2024a. How artificial intelligence will transform project management in the age of digitization: a systematic literature review. *Management Review Quarterly*.

NENNI, M. E., DE FELICE, F., DE LUCA, C. & FORCINA, A. 2024b. How artificial intelligence will transform project management in the age of digitization: a systematic literature review. *Management Review Quarterly*, 1-48.

NEWELL, A. & SIMON, H. A. 1961. Computer Simulation of Human Thinking. *Science,* 134, 2011-2017.

NEWELL, A. & SIMON, H. A. 1972. *Human problem solving*, Prentice-hall Englewood Cliffs, NJ.

NIEDERMAN, F. 2021. Project management: openings for disruption from AI and advanced analytics. *Information Technology & People,* 34, 1570-1599.

NODA, T. & BOWER, J. L. 1996. Strategy making as iterated processes of resource allocation. *Strategic management journal,* 17, 159-192.

NORONHA, S. & SARMA, V. 1991. Knowledge-based approaches for scheduling problems: A survey. *IEEE Transactions on Knowledge and Data Engineering,* 3, 160-171.

NOVEMBRI, G. & ROSSINI, F. L. 2020. Swarm modelling framework to improve design support systems capabilities. *Journal of Information Technology in Construction,* 25, 398-415.

NYQVIST, R., PELTOKORPI, A. & SEPPÄNEN, O. 2024. Can ChatGPT exceed humans in construction project risk management? *Engineering, Construction and Architectural Management,* 31, 223-243.

OHLERT, C. R. & WEIßENBERGER, B. E. 2020. Debiasing escalation of commitment: the effectiveness of decision aids to enhance de-escalation. *Journal of management control,* 30, 405-438.

OJIAKO, U., CHIPULU, M., ALMEILE, A. M., IKA, L., BASHIR, H., MARSHALL, A. & ALRAEESI, E. J. H. 2023. Variations in critical success factors of PPP-procured construction projects over lifecycle phases. *Production Planning & Control*, 1-28.

OJIAKO, U., CHIPULU, M., MARSHALL, A. & BASHIR, H. 2021. Public policy and projects: Impact of intranational jurisdictional concurrency on construction disputes. *Journal of Legal Affairs and Dispute Resolution in Engineering and Construction,* 13, 04521005.

OLAWALE, Y. & SUN, M. 2013. PCIM: Project control and inhibiting-factors management model. *Journal of management in engineering,* 29, 60-70.

OLAWALE, Y. & SUN, M. 2015. Construction project control in the UK: Current practice, existing problems and recommendations for future improvement. *International Journal of Project Management,* 33, 623-637.

OLIVEIRA, R. M. A., SANT'ANNA, Â. M. O. & DA SILVA, P. H. F. 2024. Explainable machine learning models for defects detection in industrial processes. *Computers & Industrial Engineering,* 192, 110214.

OLIVER, P. 2010. *The student's guide to research ethics*, McGraw-Hill Education (UK).

OLSON, D. L. 2020. *Quantitative Tools of Project Management,* New York, UNITED STATES, Business Expert Press.

OMRANI, N., RIVIECCIO, G., FIORE, U., SCHIAVONE, F. & AGREDA, S. G. 2022. To trust or not to trust? An assessment of trust in AI-based systems: Concerns, ethics and contexts. *Technological Forecasting and Social Change,* 181, 121763.

ONAL, S. & KULAVUZ-ONAL, D. 2024. A Cross-Disciplinary Examination of the Instructional Uses of ChatGPT in Higher Education. *Journal of Educational Technology Systems,* 52, 301-324.

ORMEROD, R. 2020a. The fitness and survival of the OR profession in the age of artificial intelligence. *Journal of the Operational Research Society,* 72**,** 4-22.

ORMEROD, R. 2020b. The fitness and survival of the OR profession in the age of artificial intelligence. *Journal of the Operational Research Society*.

ORMEROD, R. 2021. The fitness and survival of the OR profession in the age of artificial intelligence. *Journal of the Operational Research Society,* 72**,** 4-22.

OZUMBA, A. O., OJIAKO, U., SHAKANTU, W., MARSHALL, A. & CHIPULU, M. 2019. Process need areas and technology adoption in construction site management. *Journal of construction in developing countries,* 24**,** 123-155.

PADALKAR, M. & GOPINATH, S. 2016. Six decades of project management research: Thematic trends and future opportunities. *International Journal of Project Management,* 34**,** 1305-1321.

PALA, Ö., VRIENS, D. J. & VENNIX, J. A. 2015. Causal loop diagrams as a de-escalation technique. *Journal of the Operational Research Society,* 66**,** 593-601.

PAN, G. & PAN, S. L. 2011. Transition to IS project de-escalation: An exploration into management executives' influence behaviors. *IEEE Transactions on Engineering Management,* 58**,** 109-123.

PAN, G., PAN, S. L. & NEWMAN, M. 2008. Managing information technology project escalation and de-escalation: An approach-avoidance perspective. *IEEE Transactions on Engineering Management,* 56**,** 76-94.

PAN, G. S., PAN, S. L. & FLYNN, D. 2004. De-escalation of commitment to information systems projects: a process perspective. *The Journal of Strategic Information Systems,* 13**,** 247-270.

PAN, S. L., PAN, G. S. C., NEWMAN, M. & FLYNN, D. 2006. Escalation and de-escalation of commitment to information systems projects: Insights from a project evaluation model. *European Journal of Operational Research,* 173**,** 1139-1160.

PARK, C., IM, G. & KEIL, M. 2008. Overcoming the mum effect in IT project reporting: Impacts of fault responsibility and time urgency. *Journal of the Association for Information Systems,* 9**,** 1.

PATANAKUL, P., IEWWONGCHAROEN, B. & MILOSEVIC, D. 2010. An empirical study on the use of project management tools and techniques across project life-cycle and their impact on project success. *Journal of General management,* 35**,** 41-66.

PELLERIN, R. & PERRIER, N. 2019. A review of methods, techniques and tools for project planning and control. *International Journal of Production Research,* 57**,** 2160-2178.

PELLERIN, R., PERRIER, N. & BERTHAUT, F. 2020. A survey of hybrid metaheuristics for the resource-constrained project scheduling problem. *European Journal of Operational Research,* 280**,** 395-416.

PEREIRA, J., VARAJÃO, J. & TAKAGI, N. 2022. Evaluation of Information Systems Project Success – Insights from Practitioners. *Information Systems Management,* 39**,** 138-155.

PETTICREW, M. & ROBERTS, H. 2008. *Systematic reviews in the social sciences: A practical guide*, John Wiley & Sons.

PHILLIPS-WREN, G., POWER, D. J. & MORA, M. 2019. Cognitive bias, decision styles, and risk attitudes in decision making and DSS. *Journal of Decision Systems,* 28**,** 63-66.

PINTO, J. K. 2013. *Project Management, Achieving Competitive Advantage Global Edition : Pearson College*, Pearson Education UK.

PINTO, J. K., DAVIS, K., IKA, L. A., JUGDEV, K. & ZWIKAEL, O. 2022. Coming to terms with project success: Current perspectives and future challenges. *International Journal of Project Management,* 40**,** 831-834.

PITT, J., ANDERTON, M. & CUNNINGHAM, J. 1996. Normalized interactions between autonomous agents: A case study in inter-organizational project management. *Computer Supported Cooperative Work,* 5**,** 201-222.

PLAZA, M. & TURETKEN, O. 2009. A model-based DSS for integrating the impact of learning in project control. *Decision Support Systems,* 47**,** 488-499.

POLLACK, J., HELM, J. & ADLER, D. 2018. What is the Iron Triangle, and how has it changed? *International journal of managing projects in business,* 11**,** 527-547.

POMEROL, J.-C. 1997. Artificial intelligence and human decision making. *European Journal of Operational Research,* 99**,** 3-25.

POMEROL, J.-C. & ADAM, F. Practical decision making–From the legacy of Herbert Simon to decision support systems. Actes de la Conférence Internationale IFIP TC8/WG8, 2004. 647-657.

POWELL, T. C., LOVALLO, D. & FOX, C. R. 2011. Behavioral strategy. *Strategic Management Journal,* 32**,** 1369-1386.

PRADHAN, A. & AKINCI, B. 2012. Planning-based approach for fusing data from multiple sources for construction productivity monitoring. *Journal of computing in civil engineering,* 26**,** 530-540.

PURVIS, R. L., MCCRAY, G. E. & ROBERTS, T. L. 2004. Heuristics and biases in information systems project management. *Engineering Management Journal,* 16**,** 19-27.

QAZI, A. & SIMSEKLER, M. C. E. 2021. Risk assessment of construction projects using Monte Carlo simulation. *International Journal of Managing Projects in Business,* ahead-of-print.

RAHMANDAD, H. & HU, K. 2010. Modeling the rework cycle: capturing multiple defects per task. *System Dynamics Review,* 26**,** 291-315.

RAI, A. 2020. Explainable AI: From black box to glass box. *Journal of the Academy of Marketing Science,* 48**,** 137-141.

RAZ, T. & EREL, E. 2000. Optimal timing of project control points. *European Journal of Operational Research,* 127**,** 252-261.

REPENNING, N. P. 2000. A dynamic model of resource allocation in multi-project research and development systems. *System Dynamics Review: The Journal of the System Dynamics Society,* 16**,** 173-212.

REVILLA, E., SAENZ, M. J., SEIFERT, M. & MA, Y. 2023. Human–Artificial Intelligence Collaboration in Prediction: A Field Experiment in the Retail Industry. *Journal of Management Information Systems,* 40**,** 1071-1098.

ROBERTS, E. B. 1977. Strategies for effective implementation of complex corporate models. *Interfaces,* 8**,** 26-33.

ROBEY, D., SMITH, L. A. & VIJAYASARATHY, L. R. 1993. Perceptions of Conflict and Success in Information Systems Development Projects. *Journal of Management Information Systems,* 10**,** 123-140.

RODRIGUES, A. & BOWERS, J. 1996. The role of system dynamics in project management. *International Journal of Project Management,* 14**,** 213-220.

RODRIGUES, A. G. 2000. *The Application of System Dynamics to Project Management An Integrated Methodology (SYDPIM).* PhD, University of Strathclyde.

RODRIGUES, A. G. & WILLIAMS, T. M. 1998. System dynamics in project management: assessing the impacts of client behaviour on project performance. *Journal of the operational research society,* 49**,** 2-15.

ROLSTADÅS, A., TOMMELEIN, I., MORTEN SCHIEFLOE, P. & BALLARD, G. 2014. Understanding project success through analysis of project management approach. *International Journal of Managing Projects in Business,* 7**,** 638-660.

ROSENTHAL-SABROUX, C. & ZARATÉ, P. 1997. Artificial intelligence tools for decision support systems. *European Journal of Operational Research,* 103**,** 275-276.

ROSSI, F. 2018. Building trust in artificial intelligence. *Journal of international affairs,* 72**,** 127-134.

ROTH, S. & HENDRICKSON, C. 1991. Computer-generated explanations in project management systems. *Journal of Computing in Civil Engineering,* 5**,** 231-244.

ROYSTON, G. 2013. Operational Research for the Real World: big questions from a small island. *Journal of the Operational Research Society,* 64**,** 793-804.

ROZENES, S., VITNER, G. & SPRAGGETT, S. 2006. Project control: literature review. *Project management journal,* 37**,** 5-14.

RUSSELL, S. J. & NORVIG, P. 2016. *Artificial intelligence: a modern approach*, Malaysia; Pearson Education Limited.

SABEGHI, N., TAREGHIAN, H. R., DEMEULEMEESTER, E. & TAHERI, H. 2015. Determining the timing of project control points using a facility location model and simulation. *Computers & Operations Research,* 61**,** 69-80.

SAFFARIZADEH, K., KEIL, M. & MARUPING, L. 2024. Relationship Between Trust in the AI Creator and Trust in AI Systems: The Crucial Role of AI Alignment and Steerability. *Journal of Management Information Systems,* 41**,** 645-681.

SALIH, A. M., RAISI-ESTABRAGH, Z., GALAZZO, I. B., RADEVA, P., PETERSEN, S. E., LEKADIR, K. & MENEGAZ, G. 2024. A perspective on explainable artificial intelligence methods: Shap and lime. *Advanced Intelligent Systems***,** 2400304.

SÁNCHEZ, M. G., LALLA-RUIZ, E., GIL, A. F., CASTRO, C. & VOß, S. 2023. Resource-constrained multi-project scheduling problem: A survey. *European Journal of Operational Research,* 309**,** 958-976.

SANCHEZ, O. P., TERLIZZI, M. A. & DE MORAES, H. R. D. O. C. 2017. Cost and time project management success factors for information systems development projects. *International Journal of Project Management,* 35**,** 1608-1626.

SANTOS, J. I., PEREDA, M., AHEDO, V. & GALÁN, J. M. 2023. Explainable machine learning for project management control. *Computers & Industrial Engineering,* 180**,** 109261.

SARANYA, A. & SUBHASHINI, R. 2023. A systematic review of Explainable Artificial Intelligence models and applications: Recent developments and future trends. *Decision analytics journal,* 7**,** 100230.

SARMA, V. V. S. 1994. Decision making in complex systems. *Systems Practice,* 7**,** 399-407.

SAUNDERS, M., LEWIS, P. & THORNHILL, A. 2009. *Research methods for business students*, Pearson education.

SAUNDERS, M. N. K. 2012. Choosing research participants. *Qualitative organizational research: Core methods and current challenges***,** 35-52.

SAUNDERS, M. N. K., LEWIS, P. & THORNHILL, A. 2015. *Research Methods for Business Students,* Harlow, United Kingdom, UNITED KINGDOM, Pearson Education Limited.

SAVAGE, L. J. 1954. *The Foundations of Statistics,* New york, Wiley.

SAVOLAINEN, P., AHONEN, J. J. & RICHARDSON, I. 2015. When did your project start? – The software supplier's perspective. *Journal of Systems and Software,* 104**,** 32-40.

SCHAFFERNICHT, M. & GROESSER, S. N. 2011. A comprehensive method for comparing mental models of dynamic systems. *European journal of operational research,* 210**,** 57-67.

SCHWALBE, K. 2009. *Introduction to project management*, Course Technology Cengage Learning Boston.

SERVRANCKX, T., COELHO, J. & VANHOUCKE, M. 2024. A genetic algorithm for the Resource-Constrained Project Scheduling Problem with Alternative Subgraphs using a boolean satisfiability solver. *European Journal of Operational Research,* 316**,** 815-827.

SERVRANCKX, T. & VANHOUCKE, M. 2019. A tabu search procedure for the resource-constrained project scheduling problem with alternative subgraphs. *European Journal of Operational Research,* 273**,** 841-860.

SHEN, Y., BROOKES, N., LATTUF FLORES, L. & BRETTSCHNEIDER, J. 2024. Data analytics for project delivery: unlocking the potential of an emerging field. *International Journal of Managing Projects in Business,* 17**,** 302-337.

SHENHAR, A. J., DVIR, D., LEVY, O. & MALTZ, A. C. 2001. Project success: a multidimensional strategic concept. *Long range planning,* 34**,** 699-725.

SHIM, J. P., WARKENTIN, M., COURTNEY, J. F., POWER, D. J., SHARDA, R. & CARLSSON, C. 2002. Past, present, and future of decision support technology. *Decision support systems,* 33**,** 111-126.

SHIN, D. 2020. User perceptions of algorithmic decisions in the personalized AI system: perceptual evaluation of fairness, accountability, transparency, and explainability. *Journal of Broadcasting & Electronic Media,* 64**,** 541-565.

SHIN, D., CHOTIYAPUTTA, V. & ZAID, B. 2022. The effects of cultural dimensions on algorithmic news: How do cultural value orientations affect how people perceive algorithms? *Computers in Human Behavior,* 126**,** 107007.

SHIN, D. & PARK, Y. J. 2019. Role of fairness, accountability, and transparency in algorithmic affordance. *Computers in Human Behavior,* 98**,** 277-284.

SHORE, B. 2008. Systematic Biases and Culture in Project Failures. *Project Management Journal,* 39**,** 5-16.

SIDDAWAY, A. 2014. What is a systematic literature review and how do I do one. *University of Stirling,* 1**,** 1-13.

SILVERMAN, D. 2020. *Qualitative research*, Sage Publications Limited.

SIMON, H. A. 1947. *Administrative behavior: A study of decision-making processes in administrative organization,* New York, Macmillian.

SIMON, H. A. 1965. *The shape of automation for men and management*, Harper & Row New York.

SIMON, H. A. 1972. Theories of bounded rationality. *Decision and organization,* 1**,** 161-176.

SIMON, H. A. Artificial Intelligence Systems That Understand. IJCAI, 1977a. 1059-1073.

SIMON, H. A. 1977b. Thinking by computers. *Models of Discovery*. Springer.

SIMON, H. A., DANTZIG, G. B., HOGARTH, R., PLOTT, C. R., RAIFFA, H., SCHELLING, T. C., SHEPSLE, K. A., THALER, R., TVERSKY, A. & WINTER, S. 1987. Decision making and problem solving. *Interfaces,* 17**,** 11-31.

SIQUEIRA, I. 1999. Automated Cost Estimating System Using Neural Networks. *Project Management Journal,* 30**,** 11-18.

SKURIDIN, A. & WYNN, M. 2024. Chatbot Design and Implementation: Towards an Operational Model for Chatbots. *Information (Switzerland),* 15.

SLEESMAN, D. J. 2019. Pushing through the tension while stuck in the mud: Paradox mindset and escalation of commitment. *Organizational Behavior and Human Decision Processes,* 155**,** 83-96.

SLEESMAN, D. J., CONLON, D. E., MCNAMARA, G. & MILES, J. E. 2012. Cleaning up the big muddy: A meta-analytic review of the determinants of escalation of commitment. *Academy of Management Journal,* 55**,** 541-562.

SLEESMAN, D. J., LENNARD, A. C., MCNAMARA, G. & CONLON, D. E. 2018. Putting escalation of commitment in context: A multilevel review and analysis. *Academy of Management Annals,* 12**,** 178-207.

SNYDER, H. 2019. Literature review as a research methodology: An overview and guidelines. *Journal of Business Research,* 104**,** 333-339.

SÖDERBERG, E. 2020. Project initiation as the beginning of the end: Mediating temporal tensions in school's health projects. *International Journal of Project Management,* 38**,** 343-352.

SON, J. & ROJAS, E. M. 2011. Impact of optimism bias regarding organizational dynamics on project planning and control. *Journal of construction engineering and management,* 137**,** 147-157.

SONG, J., MARTENS, A. & VANHOUCKE, M. 2020. The impact of a limited budget on the corrective action taking process. *European Journal of Operational Research,* 286**,** 1070-1086.

SONG, J., MARTENS, A. & VANHOUCKE, M. 2022. Using Earned Value Management and Schedule Risk Analysis with resource constraints for project control. *European Journal of Operational Research,* 297**,** 451-466.

SONG, L. Earned Value Management: a global and cross-industry perspective on current EVM practice. 2010. Project Management Institute.

STAW, B. M. 1981. The escalation of commitment to a course of action. *Academy of management Review,* 6**,** 577-587.

STAW, B. M. 1997. The escalation of commitment: An update and appraisal. *In:* SHAPIRA, Z. (ed.) *Organizational decision making.* New York, NY: Cambridge University Press.

STAW, B. M. & ROSS, J. 1987. Behavior in escalation situations: Antecedents, prototypes, and solutions. *Research in organizational behavior*.

STERMAN, J. D. 1992. System Dynamics Modeling for Project Management. *Sloan School of Management, MIT*.

STERMAN, J. D. 2000. *Business dynamics: systems thinking and modeling for a complex world,* New York, McGraw-Hill.

STINGL, V. & GERALDI, J. 2017a. Errors, lies and misunderstandings: Systematic review on behavioural decision making in projects. *International Journal of Project Management,* 35**,** 121-135.

STINGL, V. & GERALDI, J. 2017b. Toolbox for uncertainty; Introduction of adaptive heuristics as strategies for project decision making. *International Research network on Organizing by projects, IRNOP*.

STINGL, V. & GERALDI, J. 2021. A research agenda for studying project decision-behaviour through the lenses of simple heuristics. *Technological Forecasting and Social Change,* 162**,** 120367.

STRANG, K. D. & VAJJHALA, N. R. 2023. Mining Project Failure Indicators From Big Data Using Machine Learning Mixed Methods. *International Journal of Information Technology Project Management,* 14.

STRAUSS, A. & CORBIN, J. 1998. *Basics of qualitative research techniques*, Sage publications Thousand Oaks, CA.

TAM, C., MOURA, E. J. D. C., OLIVEIRA, T. & VARAJÃO, J. 2020. The factors influencing the success of on-going agile software development projects. *International Journal of Project Management,* 38**,** 165-176.

TAVARES, L. V. 2002. A review of the contribution of Operational Research to Project Management. *European Journal of Operational Research,* 136**,** 1-18.

TAYLOR, P. 2021. *AI and the project manager: How the rise of artificial intelligence will change your world*, Routledge.

TERLIZZI, M. A., DE SOUZA MEIRELLES, F. & DE MORAES, H. R. O. C. 2016. Barriers to the use of an IT Project Management Methodology in a large financial institution. *International journal of project management,* 34**,** 467-479.

TIMMERMANS, S. & TAVORY, I. 2012. Theory construction in qualitative research: From grounded theory to abductive analysis. *Sociological theory,* 30**,** 167-186.

TIWANA, A. & KEIL, M. 2009. Control in Internal and Outsourced Software Projects. *Journal of Management Information Systems,* 26**,** 9-44.

TIWANA, A., WANG, J., KEIL, M. & AHLUWALIA, P. 2007. The bounded rationality bias in managerial valuation of real options: Theory and evidence from IT projects. *Decision Sciences,* 38**,** 157-181.

TODOROVIĆ, M. L., PETROVIĆ, D. Č., MIHIĆ, M. M., OBRADOVIĆ, V. L. & BUSHUYEV, S. D. 2015. Project success analysis framework: A knowledge-based approach in project management. *International Journal of Project Management,* 33**,** 772-783.

TOMINC, P., OREŠKI, D., ČANČER, V. & ROŽMAN, M. 2024. Statistically Significant Differences in AI Support Levels for Project Management between SMEs and Large Enterprises. *AI (Switzerland),* 5**,** 136-157.

TOMINC, P., OREŠKI, D. & ROŽMAN, M. 2023. Artificial Intelligence and Agility-Based Model for Successful Project Implementation and Company Competitiveness. *Information (Switzerland),* 14.

TOMOAIA-COTISEL, A., ALLEN, S. D., KIM, H., ANDERSEN, D. & CHALABI, Z. 2022. Rigorously interpreted quotation analysis for evaluating causal loop diagrams in Late-Stage conceptualization. *System Dynamics Review,* 38**,** 41-80.

TORRES, J. P., KUNC, M. & O'BRIEN, F. 2017. Supporting strategy using system dynamics. *European Journal of Operational Research,* 260**,** 1081-1094.

TRANFIELD, D., DENYER, D. & SMART, P. 2003. Towards a methodology for developing evidence-informed management knowledge by means of systematic review. *British journal of management,* 14**,** 207-222.

TRIETSCH, D. & BAKER, K. R. 2012. PERT 21: Fitting PERT/CPM for use in the 21st century. *International Journal of Project Management,* 30**,** 490-502.

TURBAN, E., ARONSON, J. E. & LIANG, T. P. 2005. Decision Support Systems and Intelligent System,(Sistem Pendukung Keputusan dan Sistem Cerdas) Ed. 7. Jld. 2.

TURNER, J. R. & MÜLLER, R. 2003. On the nature of the project as a temporary organization. *International Journal of Project Management,* 21**,** 1-8.

TVERSKY, A. 1975. A critique of expected utility theory: Descriptive and normative considerations. *Erkenntnis***,** 163-173.

TVERSKY, A. & KAHNEMAN, D. 1974. Judgment under Uncertainty: Heuristics and Biases: Biases in judgments reveal some heuristics of thinking under uncertainty. *science,* 185**,** 1124-1131.

TVERSKY, A. & KAHNEMAN, D. 2023. ... people rely on a limited number of heuristic principles which reduce the complex tasks of assessing probabilities and predicting values to simpler judgmental opera-tions. In general, these heuristics are quite useful, but sometimes they lead to severe and systematic errors. *Advanced Introduction to Behavioral Finance***,** 36.

UDDIN, S., ONG, S. & LU, H. 2022. Machine learning in project analytics: a data-driven framework and case study. *Scientific Reports,* 12.

VAN DEN ENDE, L. & VAN MARREWIJK, A. 2014. The ritualization of transitions in the project life cycle: A study of transition rituals in construction projects. *International Journal of Project Management,* 32**,** 1134-1145.

VAN OORSCHOT, K. E., AKKERMANS, H., SENGUPTA, K. & VAN WASSENHOVE, L. N. 2013. Anatomy of a decision trap in complex new product development projects. *Academy of Management Journal,* 56**,** 285-307.

VANHOUCKE, M. 2012a. Measuring the efficiency of project control using fictitious and empirical project data. *International Journal of Project Management,* 30**,** 252-263.

VANHOUCKE, M. 2012b. *Project management with dynamic scheduling*, Springer.

VANHOUCKE, M. 2013. An overview of recent research results and future research avenues using simulation studies in project management. *International Scholarly Research Notices,* 2013.

VANHOUCKE, M. & COELHO, J. 2024. A matheuristic for the resource-constrained project scheduling problem. *European Journal of Operational Research,* 319**,** 711-725.

VANHOUCKE, M., COELHO, J. & BATSELIER, J. 2016. An overview of project data for integrated project management and control. *Journal of Modern Project Management,* 3**,** 6-21.

VAROUQA, I. F. 2021. Using artificial intelligence and computation Enhanced apply in neural network. *Journal of Applied Science and Engineering (Taiwan),* 24**,** 763-770.

VEGA-VELÁZQUEZ, M. Á., GARCÍA-NÁJERA, A. & CERVANTES, H. 2018. A survey on the software project scheduling problem. *International Journal of Production Economics,* 202**,** 145-161.

VIDGEN, R., HINDLE, G. & RANDOLPH, I. 2020. Exploring the ethical implications of business analytics with a business ethics canvas. *European Journal of Operational Research,* 281**,** 491-501.

VIKTOR, M., ANNA, K. & OLGA, M. 2021. Development of a model for evaluating the effectiveness of innovative startups based on information cycles and using neural networks. *Indonesian Journal of Electrical Engineering and Computer Science,* 23**,** 396-404.

VON NEUMANN, J. & MORGENSTERN, O. 1947. Theory of games and economic behavior, 2nd rev.

WACHNIK, B. 2022. Analysis of the use of artificial intelligence in the management of Industry 4.0 projects. The perspective of Polish industry. *Production Engineering Archives,* 28**,** 56-63.

WALKER, A. 2015. *Project management in construction*, John Wiley & Sons.

WALLIMAN, N. 2010. *Research methods: The basics*, Routledge.

WALSH, V. 1996. Rationality, allocation, and reproduction. *OUP Catalogue*.

WANG, C., WOOD, L. C., ABDUL-RAHMAN, H. & LEE, Y. L. 2016. When traditional information technology project managers encounter the cloud: Opportunities and dilemmas in the transition to cloud services. *International Journal of Project Management,* 34**,** 371-388.

WANG, L., KUNC, M. & BAI, S.-J. 2017. Realizing value from project implementation under uncertainty: An exploratory study using system dynamics. *International Journal of Project Management,* 35**,** 341-352.

WANG, L., KUNC, M. & LI, J. 2020a. Project portfolio implementation under uncertainty and interdependencies: A simulation study of behavioural responses. *Journal of the Operational Research Society,* 71**,** 1426-1436.

WANG, L., LI, J. & LI, C. 2020b. Modeling human behaviors in project management: Insights from the literature review. *Behavioral Operational Research: A Capabilities Approach*.

WAUTERS, M. & VANHOUCKE, M. 2014. Support Vector Machine Regression for project control forecasting. *Automation in Construction,* 47**,** 92-106.

WAUTERS, M. & VANHOUCKE, M. 2016. A comparative study of Artificial Intelligence methods for project duration forecasting. *Expert Systems with Applications,* 46**,** 249-261.

WAUTERS, M. & VANHOUCKE, M. 2017. A Nearest Neighbour extension to project duration forecasting with Artificial Intelligence. *European Journal of Operational Research,* 259**,** 1097-1111.

WESTLAND, J. 2007. *The Project Management Life Cycle: A Complete Step-by-step Methodology for Initiating Planning Executing and Closing the Project*, Kogan Page Publishers.

WHITE, L. 2016. Behavioural operational research: Towards a framework for understanding behaviour in OR interventions. *European Journal of Operational Research,* 249**,** 827-841.

WHITE, L., KUNC, M., BURGER, K. & MALPASS, J. 2020. Behavioral Operational Research: A Capabilities Approach. *In:* WHITE, L., KUNC, M., BURGER, K. & MALPASS, J. (eds.) *Behavioral Operational Research: A Capabilities Approach*. Cham: Springer International Publishing.

WILLEMS, L. L. & VANHOUCKE, M. 2015. Classification of articles and journals on project control and earned value management. *International Journal of Project Management,* 33**,** 1610-1634.

WILLIAMS, T. 2003. The contribution of mathematical modelling to the practice of project management. *IMA Journal of Management Mathematics,* 14**,** 3-30.

WILLIAMS, T., ACKERMANN, F. & EDEN, C. 2003. Structuring a delay and disruption claim: An application of cause-mapping and system dynamics. *European Journal of Operational Research,* 148**,** 192-204.

WILSON, H. J. & DAUGHERTY, P. R. 2018. Collaborative intelligence: humans and AI are joining forces. *Harvard Business Review,* 96**,** 114-123.

WINCH, G. M. 2013. Escalation in major projects: Lessons from the Channel Fixed Link. *International Journal of Project Management,* 31**,** 724-734.

WINCH, G. M. & KELSEY, J. 2005. What do construction project planners do? *International Journal of Project Management,* 23**,** 141-149.

WU, C., WANG, X. & JIANG, L. 2014. *Optimizations in project scheduling: A state-of-art survey*, Kluwer Academic Publishers.

XIANG, L., TAN, Y., SHEN, G. & JIN, X. 2022. Applications of multi-agent systems from the perspective of construction management: A literature review. *Engineering, Construction and Architectural Management,* 29**,** 3288-3310.

XIE, L.-L., CHEN, Y., WU, S., CHANG, R.-D. & HAN, Y. 2024. Knowledge extraction for solving resource-constrained project scheduling problem through decision tree. *Engineering, Construction and Architectural Management,* 31**,** 2852-2877.

XU, F. & LIN, S. P. 2016. Theoretical framework of Fuzzy-AI model in quantitative project management. *Journal of Intelligent and Fuzzy Systems,* 30**,** 509-521.

YANG, M. M., YANG, F. & LI, X. 2023. Open innovation and de-escalation of commitment in underperforming new product development projects. *Journal of Business Research,* 164**,** 113989.

YASEEN, Z. M., ALI, Z. H., SALIH, S. Q. & AL-ANSARI, N. 2020. Prediction of risk delay in construction projects using a hybrid artificial intelligence model. *Sustainability (Switzerland),* 12.

YEARWORTH, M. & WHITE, L. 2013. The uses of qualitative data in multimethodology: Developing causal loop diagrams during the coding process. *European Journal of Operational Research,* 231**,** 151-161.

ZADEH, L. A. 1988. Fuzzy logic. *Computer,* 21**,** 83-93.

ŻELECHOWSKA, D., ŻYLUK, N. & URBAŃSKI, M. 2020. Find Out A New Method to Study Abductive Reasoning in Empirical Research. *International Journal of Qualitative Methods,* 19**,** 1609406920909674.

ZHANG, G. P., KEIL, M., RAI, A. & MANN, J. 2003. Predicting information technology project escalation: A neural network approach. *European Journal of Operational Research,* 146**,** 115-129.

ZHANG, J., LI, L., DEMEULEMEESTER, E. & ZHANG, H. 2024. A three-dimensional spatial resource-constrained project scheduling problem: Model and heuristic. *European Journal of Operational Research,* 319**,** 943-966.

ZHENG, X., LIU, Y., JIANG, J., THOMAS, L. M. & SU, N. 2021. Predicting the litigation outcome of ppp project disputes between public authority and private partner using an ensemble model. *Journal of Business Economics and Management,* 22**,** 320-345.

ZHOU, Z. & ZOU, Y. 2021. Research on grey situation decision in the context of system analysis of village planning projects using fuzzy TOPSIS. *Journal of Intelligent & Fuzzy Systems,* 40**,** 8185-8195.