Project Trade-Off Decisions
The Gap between Reality and the Academic World

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Abstract

This paper draws attention to project trade-offs significance in project management and critically reviews the current state of the knowledge on the elements to be considered and the methods to resolve trade-off decisions. Traditionally the elements to be considered in trade-offs are mainly limited to time and cost and to some extent quality or risk or the well-known Project Triangle. The trade-off methods are also dominantly developed based on mathematical models familiar in Operations Research. The limitations of traditional approaches in identifying trade-off elements; the constraints of the common methods of trade-off resolution; and the necessity of compatibility between resolution methods and features of trade-off decisions are highlighted. The researchers' approach and methodology to fill the gap between the realities of project trade-off decisions mainly based on the compatibility of the decision problem characteristics and capabilities of the decision making method are described.

Keywords: project trade-off, trade-off elements, trade-off methods, project triangle, operations research

1. Introduction

The general theme for this study is making critical decisions in projects, notably '*trade-off decisions'*. Decision-making (DM) can be considered as one of the most influential and important skills for a project manager (Wideman, 2001) as he/she needs to use it on a daily basis (Lewis, 2008). Regarding its significance in project management (PM), Virine and Trumper (2008, xv) state that "project management is the art of making the right decisions" and Schuyler (2001) refers to it as one of the most important issues in project success.

Throughout a project's lifecycle, management have to make a large number of different decisions in terms of outcomes, consequences and their effect on project success or failure. '*Trade-off decisions'* can be considered as some of the most challenging decisions in a project's journey. It is generally accepted that these types of decisions are complex and have significant importance in project success or failure (Virine and Trumper, 2008). Belassi and Tukel (1996, p.150) include the project manager's *ability to do tradeoffs* as one of the project success factors. Shenhar *et al.* (1996) emphasize *success criteria* as the foundation of project tradeoffs both in the launch of and during the project. The methodology for project tradeoffs is perceived as a facilitator of project success by Babu and Suresh (1996).

The general approach to identifying the project elements involved in this type of decisions and the methods suggested by academia to resolve the trade-off problems have been critically reviewed in this paper. The paper is a snapshot of an ongoing research study which aims at filling the gaps between the current state of knowledge in this field and the reality of trade-off decisions in project environments.

2. Theoretical framework

2.1 Project trade-off definition

'Decisions' to be made during a project might vary in terms of their significance and impact. Some decisions are routine and not very sensitive, might affect or be affected by a small group of project stakeholders, or their outcomes may fit within the project's assigned resources and limitations. Making such decisions usually does not require a significant amount of time or effort from project manager.

However, project managers or (whoever the decision-maker may be) might encounter *one-off* decisions demanding a considerable amount of time and effort to analyse and make. Such decisions might affect a large number of project stakeholders or be affected by them. It is possible that the outcomes of such decisions would lead the project to go beyond its assigned resources and constraints. The way of handling such critical decisions, and their outcomes might have a significant impact on the assessment of the project's success or failure. This type of decision usually requires a '*trade-off'* in order to find a resolution to the problem. Thus they are referred to as *'Trade-off Decisions'* in this study.

Traditionally, the concept of '*trade-off*' in Project Management tends to refer specifically to problems which demand finding a balance between the project's '*time* and *cost'*. Such challenges have been said to be the origin of the Critical Path Method (CPM) developed in 1950s (Pollack-Johnson and Liberatore, 2006). In general, a tradeoff comprises 'making a decision'; hence, it can be perceived as a type of DM problem and not simply a controlling or scheduling tool like CPM.

In PM literature *time* and *cost* elements of projects are variously introduced as 'project resources' or 'objectives'. In terms of '*resources'*, tradeoffs might be necessary due to their scarcity (Dobson, 2004) and when *'objectives'* are considered, tradeoffs serve as a balancing act when these objectives conflict (Williams, 2002; Lock, 2007). In fact, if a project went well according to the plan, had the benefit of unlimited resources, or all the stakeholders had the same expectations from the project, there would not be a need to make any trade-off (Williams, 2002; Kerzner, 2006). However, in the more recent PM literature there is a broader view on project trade-offs that focuses on the necessity of keeping a balance between the project's real '*objectives'* (Virine and Trumper, 2008; and Williams, 2002), i.e. not just limited to *time* and *cost.* These are indeed different or even conflicting *'objectives'* of the project's stakeholders.

2.2 Elements of trade-off decisions

Primarily, *Time* and *cost* were known as the main elements of project tradeoffs. However, after invention of the well-known project '*Triangle',* its elements i.e. *cost, time* and *quality/ performance* were introduced as trade-off's basis (e.g. Barnes, 1988; Lock, 2007; and Afshar *et al*., 2007). Dobson (2004, xii) argues the significance of these triple constraints as: "the core of the most crucial decisions about a project" and highlights their significance in analyzing project tradeoffs.

Nevertheless, there is research stating that project tradeoffs should consider *other factors* besides the '*Triangle'* elements (Babu and Suresh, 1996; Shenhar *et al.*, 1996; Leu *et al*., 2001; and Pollack-Johnson and Liberatore, 2006). However, a review of PM literature on trade-off methods reveals that the recognition of additional factors has not effectively directed the approach and focus of the PM researchers to enter these factors in tradeoff resolution methods. Examples of the factors beyond the project triangle elements are *market position* and *reputation of the company,* and these might have significant impact on choosing among the alternatives for a critical decision in a project.

The link between project tradeoffs and the recognition of top management and the project team's expectation had been demonstrated by Shenhar *et al.* (1996). The four elements of trade-offs suggested by Marasco (2004) are *scope, time, quality* and *resources* illustrated as a pyramid. Kerzner (2006, p.684) also introduces a number of factors affecting, or 'forcing' the tradeoffs. He does not go into details on these factors and the way they influence tradeoffs but generally categorizes the factors as 'internals' such as *reputation, market position* and *profit* and 'externals' such as *reliability, service, response* and *controls*.

2.3 Methods of trade-off decisions resolution

A considerable amount of research has aimed at developing project tradeoff methods; either based on existing approaches or proposing totally *new* ones (e.g. Deĭneko and Woeginger, 2001; Yang, 2007; and Wuliang and Chengen, 2009). These methods are predominantly based on mathematical models; mainly the ones familiar in Operations Research (OR). However, there are also other approaches such as Fuzzy Theory (e.g. Leu *et al*., 2001; and Abbasnia *et al*., 2008).

OR originated in the UK during the Second World War era and is defined as the science of the mathematical modelling of decisions (Taha, 2003). Williams (2003) states that OR has made a significant contribution towards project management for over 50 years, specifically in modelling projects and project decisions. However, he notes the difficulty of considering intangible and non-measurable factors, e.g. *market position* or *reputation*, and detachment from the reality of projects, as the major drawbacks of such mathematical models in the new era of project management. A few instances of OR models developed for project tradeoffs are Babu and Suresh (1996); Pollack-Johnson and Liberatore (2006); and Tareghian and Taheri (2006a, 2006b, 2007). The models presented by these researchers normally only deal with time-cost tradeoffs and at most include quality.

A major critique of trade-off models was raised over a decade ago by Babu and Suresh (1996). They criticized incapability of trade-off methods in dealing with the '*quality'* factor as they could not find a model in the literature to simultaneously consider the three objectives of *time, cost, quality*. The criticism was still valid ten years later, while Pollack-Johnson and Liberatore (2006) were still criticising the traditional time-cost tradeoffs for ignoring the *quality* factor (see also, Vahidi and Greenwood, 2009). Surprisingly, in reviewing the recent literature, it is still noticeable that the number of research papers focusing merely on time and cost is increasing.

Hence, one line of research on trade-off has centred around developing methods which can deal with 'quality' in their calculations. The usual approach in such studies is to 'quantify' quality and then include it in the calculations; alternatively, there are authors like Woodward (2003) who resist to the idea, suggesting that quality cannot be traded-off but should be treated as a fixed contractual 'given'.

Babu and Suresh's (1996) work involves mathematical method based on three linear programming models to overcome the problem. But Pollack-Johnson and Liberatore (2006) suggest a framework to combine different definitions of quality with their related time, cost, and priorities. They used mixed integer linear programming and goal programming for problem modelling and the Analytic Hierarchy Process (AHP) for choosing among the alternatives.

A number of tradeoff methods have also been developed based on different other approaches like Fuzzy Theory, Genetic Algorithms, Heuristics or mixed methods, and so on. Examples of these are works by Leu *et al.* (2001) and Abbasnia *et al.* (2008) which try to capture *risk* and *uncertainty* as well as *time* and *cost* elements. Leu *et al.* (2001) attempt to find the best balance between *time* and *cost,* considering the *risk levels*. Their model is based on Fuzzy Set Theory and searches for an optimal solution by Genetic Algorithms (GAs). Abbasnia *et al.* (2008) use Fuzzy Logic Theory as well as a multi-objective optimization method to consider cost uncertainties.

Tareghian and Taheri (2006a) developed a method to resolve the time-cost tradeoff in 2006, but soon after, in two subsequent papers (Tareghian and Taheri, 2006b, 2007) they included *'quality'* in their mathematical methods. These papers used (respectively) 'the fast algorithm of randomized minimum cut'; three 'inter-related integer programming models'; and 'electromagnetic scatter search' as tradeoff methods.

Marasco (2004) illustrates his suggested *four trade-off elements* as a *pyramid* and his method for resolving the trade-off involves simply calculating the pyramid's volume.

3. Nature of trade-off problems

In decision science, ever set of modelling tools and methods will target specific type of problems based on the problem features and requirements. A good understanding of the trade-off problem's nature is an essential step to be taken before selecting the proper method for its formulation and resolution. Furthermore, it provides the necessary criteria for assessing the capabilities of current resolution methods in matching with problem's characteristics. Some key features of trade-offs as a decision making problem will be discussed here.

In a critical trade-off, decision makers deal with balancing the different or even conflicting objectives of stakeholders. Hence, *multi-objectivity* can be recognized as a feature of these problems (Virine and Trumper, 2008), in fact, such a 'key influencing' feature as this might force the decision to take the form of a *'group decision making'* problem which in turn will affect the choice of DM tools and approach.

'Criteria' are essential parts of making any decision from the simplest one is daily life to the most professional ones. Normally project decision makers need to consider a set of criteria (such as time, cost, customer satisfaction, and standards, etc.) together rather than just one criterion like cost or time. Decisions such as tradeoffs, involving more than one criterion are called *multi-criteria*. It should be noted that these criteria could be tangible or intangible, (such as time vs. customer perceptions), measurable or non-measurable, (e.g. monetary benefits vs. customer satisfaction). Dealing with different kinds of criteria in one trade-off decision necessitates using the proper decision making tools and techniques developed for such types of problem.

4. Discussion

4.1 Necessity to improve trade-off' elements and methods

The current state of the knowledge on project tradeoffs in project management reveals the limitations of the traditional approaches to project trade-off decisions. Three different, though closely interrelated, aspects can be perceived for these limitations: first, the elements to be considered in a trade-off; second, the methods developed for trade-off resolution; and last but not least, the compatibility of the method with the problem's features.

4.2 The aspect of trade-off 'elements'

Based on the arguments presented so far, it can be claimed that neither the *Project Triangle* nor a *limited predefined set of elements* is a sufficient basis to serve every project trade-off decision. The logic is that even the *Project Triangle* that has been traditionally introduced as the project's important elements and the basis for trade-offs, has been subjected to criticism because of its insufficiency in reflecting the reality of projects (Gardiner and Stewart, 2000; and Dobson, 2004). Hence, other elements to be added to the Triangle elements have been proposed by Devaux, (1999); Atkinson (1999); Gardiner and Stewart (2000); Frame (2002); Nokes *et al.* (2003); Wideman (2004); Gardiner (2005); Lock (2007) and a number of other researchers.

Every project is, to a certain extent, unique and one cannot ensure that a certain set of elements will cover all trade-off situations. For example, in one situation a company's *current reputation* and in another, a firm's *long term market position* might need to be considered alongside time, cost, and so on. Hence, prescribing a predefined set of elements to include in every trade-off decision is far from the reality of projects. It seems that Frame's (2002, p.6) statement about traditional PM approach " … single-minded focus on a fixed set of tools for dealing with scheduling, budgeting, and resource allocation" is indeed valid in case of trade-off decisions.

On the other hand, the close relation between tradeoffs and project success logically necessitates that all recognisable project success elements or criteria be considered in tradeoffs. The extensive research on project success reveals that numerous factors have been suggested and several classification systems have been developed regarding success elements: as yet, however, these do not appear to have affected the approach to trade-off methods (discussed in Vahidi and Greenwood, 2009, pp. 931-932). In other words, yet the trade-off methods so far developed can merely deal with a very limited number of success elements in decisions.

4.3 The aspect of trade-off 'methods'

In terms of trade-off methods, it has been already shown that the predominantly mathematical methods mainly focus on *time, cost* and (to a limited extent) *quality, risk* or *uncertainty*. The lack of models considering *quality* in addition to *time* and *cost* has been criticised and has lead to some efforts to redress this (as described already). Nevertheless, the necessity of including *the other influencing factors* recognized in literature besides the triangle elements has remained unspoken and has attracted too little attention in PM literature.

In criticizing current tradeoff methods, Clough *et al.* (2000, pp.140-141) pinpoint the limitations and failures of the time-cost based computerized methods in construction projects' context. They associate these with 'oversimplification' of trade-off' *reality* which ultimately leads to a continued dependence on human 'judgment' and 'insight' as the most important factors in such decisions.

It is worth noting that the necessity for considering alternative/additional elements is mainly the subject of those papers that are not aimed at developing a tradeoff resolution method. In other words, when it comes to method development, the elements considered are usually restricted to the original 'triangle' (Vahidi and Greenwood, 2009).

Vahidi and Greenwood (2009) raise a major question in this regard: "whether the *tradeoff methods* are chosen based on their capability to deal with the real factors, or the *tradeoff factors* are chosen based on the capabilities of the most known or available methods?" They suggest that the evidence from literature more closely support the latter.

5. Compatibility of 'decision problem' with 'resolution method'

According to the previous discussions, project trade-off could be characterized as *multi-objective, multi-criteria,* and *group decision making* problems. These characteristics necessitate using proper tools and methods to enable the decision makers to effectively solve the problem. Ignoring any of these features in the selection and development of a method means failure in capturing the full dimensions of the problem. This in turn will lead to the development of methods which are not capable of coping holistically with the criticality of such decisions in projects.

Having reviewed a wide range of literature in the scope of this research, the authors can claim that research on project tradeoffs suffers from a lack of compatibility between problem characteristics and method capabilities. The current methods (of which examples were given before) can hardly provide a decision making environment and process that different project parties with different objectives and criteria can be involved in.

It is important to note that time, cost, quality and many other project elements which are involved in critical decisions can have different *priorities* and *values* for various stakeholders. The purely mathematical approaches which are based on quantification of these variables are not able to deal with their different facets. This might be considered as one of the issues that leads the researchers to leave such a large leeway for *human judgment* in project decisions and specifically in trade-offs.

6. Future study

This paper is based on a research in progress. The aim of the research is to fill in the gaps between the reality of project trade-off and the academic studies by developing a theoretical framework for such decisions. The approach of this research is to select and apply a project trade-off method based on the characteristics of trade-off decisions, which means it should support multi-objective/ multi-criteria decisions and can be applied in group decision making. It is perceived that this can be taken as a step to overcome some of the major deficiencies of the common mathematical models.

The empirical phase of the study will be based around a number of semi-structured interviews and case studies to accredit the model that will be developed through the study. The interviews will be conducted with highly experienced professionals in decision-making positions within multidisciplinary project environments. So far, the outcome of a few interviews confirms the fact that limiting the trade-offs to time, cost, and quality is far from the real situations. Additionally, there has been no evidence of the application of purely mathematical models in real cases.

7. Conclusions

It is widely accepted that the project trade-offs which are kind of project decisions can have considerable impact on project success and failure. The necessity of considering intangible, non-measurable factors besides the famous *project triangle's* elements has been recognized in the PM literature from one hand, and their existence in real situations is widely accepted by practitioners on the other hand. However, the research on trade-off methods reveal a large gap between the reality of such decisions and the perceived elements and developed methods for dealing with these decisions. The methods available to resolve the trade-offs are dominantly based on the old-fashioned viewpoint of limiting the project's elements and success elements to cost, time and quality/ performance and purely mathematical models to deal with these elements.

Another remarkable issue about developing a proper method is lack compatibility of the method and problem features. This can be also perceived as a deficiency in academic studies of project trade-off methods as they are detached from the characteristics of these kinds of decisions in real project environments. The tools and techniques suggested by common methods cannot fully capture the problem requirements. Hence, the models that have been developed are not extensively used in practice; or, if some of them are ever used, they are not strongly supported by examples of their application in real project situations. This all attests to a gap between reality of trade-off decisions and the academic studies.

This paper is part of a research in progress. The research is aimed at developing a method based on decision making theories, specifically multi-objective/ multi-criteria decision making models, which can better cope with trade-off problems characteristics. The theoretical study will be followed by an empirical study to examine the applicability of the suggested model in real project environments.

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