Reflexive governance architectures: considering the ethical implications of autonomous technology adoption in food supply chains

Authors

Louise Manning[1], Steve Brewer[1], Peter J. Craigon[2,3], Jeremy Frey[4], Anabel Gutierrez[5], Naomi Jacobs[6] Samantha Kanza[4], Samuel Munday[4], Justin Sacks,[6] Simon Pearson[1]

Affiliations

1. The Lincoln Institute of Agri-Food Technology, University of Lincoln, Lincoln, UK
2. Future Food Beacon of Excellence and School of Biosciences, University of Nottingham, Nottingham, UK
3. Horizon Digital Economy Research Institute, University of Nottingham, Nottingham, UK
4. School of Chemistry, Faculty of Engineering & Physical Sciences, University of Southampton, Southampton, UK
5. School of Business and Management, Royal Holloway University of London, Egham, UK
6. Imagination Lancaster, LICA, Lancaster University, Lancaster, UK

ORCIDS

Steve Brewer: https://orcid.org/0000-0002-9708-0427

sbrewer@lincoln.ac.uk

Peter Craigon: https://orcid.org/0000-0001-5081-2718

peter.craigon4@nottingham.ac.uk

Jeremy Frey: https://orcid.org/0000-0003-0842-4302

J.G.Frey@soton.ac.uk

Anabel Gutierrez Mendoza: http://orcid.org/0000-0002-3730-8282

anabel.gutierrezmendoza@rhul.ac.uk

Naomi Jacobs: https://orcid.org/0000-0003-2079-1658

naomi.jacobs@lancaster.ac.uk

Samantha Kanza: https://orcid.org/0000-0002-4831-9489

s.kanza@soton.ac.uk

Louise Manning http://orcid.org/0000-0002-9900-7303

Samuel Munday: https://orcid.org/0000-0001-5404-6934

s.a.munday@soton.ac.uk
Simon Pearson: https://orcid.org/0000-0002-4297-4837
spearson@lincoln.ac.uk
Justin Sacks: https://orcid.org/0000-0002-8643-2087
j.sacks@lancaster.ac.uk

Corresponding Author LManning@lincoln.ac.uk

Abstract

Background: The application of autonomous technology in food supply chains gives rise to a number of ethical considerations associated with the interaction between human and technology, human-technology-plant and human-technology-animal. These considerations and their implications influence technology design, the ways in which technology is applied, how the technology changes food supply chain practices, decision-making and the associated ethical aspects and outcomes.

Scope and approach: Using the concept of reflexive governance, this paper has critiqued existing reflective food-related ethical assessment tools and proposed the structural elements required for reflexive governance architectures which address both the sharing of data, and the use of artificial intelligence (AI) and machine learning in food supply chains.

Key findings and conclusions: Considering the ethical implications of using autonomous technology in real life contexts is challenging. The current approach, focusing on discrete ethical elements in isolation e.g., ethical aspects or outcomes, normative standards or ethically orientated compliance-based business strategies is not sufficient in itself. Alternatively, the application of more holistic, reflexive governance architectures can inform consideration of ethical aspects, potential ethical outcomes, in particular how they are interlinked and/or interdependent, and the need for mitigation at all lifecycle stages of technology and food product conceptualisation, design, realisation and adoption in the food supply chain. This research is of interest to those who are undertaking ethical deliberation on data sharing, and the use of AI and machine learning in food supply chains.

Keywords: data, ethical aspects, ethical outcomes, reflective governance, reflexive governance, AI, food supply

Highlights

- Autonomous technology can support decision-making in food supply chains.
- The use of autonomous technology has ethical implications.
- Ethical considerations focus on both aspects and outcomes of technology use.
- Existing governance approaches are limited by being reflective, normative, rule-based.
- Reflexive governance architectures for technology ‘concept to realisation’ are essential.

1. Introduction

Modern sociotechnical food systems and the complex legal, economic, technical and ethical considerations that they encompass, can have significant positive as well as negative consequences for society (Miller, 2013). Ethics, as a term, is derived from the Greek word "ethos" meaning conduct; customs or character (Manning, Baines & Chadd, 2006). Ethics is the basis on which principles, values, rules and standards of conduct are based (Surampalli et al., 2020). In food systems, multiple organisations and individuals operate both as direct actors (businesses who supply and purchase within the supply chain, and ultimately the consumer) and indirect actors (government, non-governmental organisations (NGOs), citizens and so forth) who influence both practices and interactions. Ethical positions can vary between these actors, and understanding their mutual and differentiated stances is important (Kirwan, Maye & Brunori, 2017). However, ethical consideration at the system level is complex, and nuanced depending on both the generalised and the specific ethical aspects and ethical outcomes associated with food supply in a given context.

Ethically orientated policy decisions, supply chain normative standards and ethical assessments often rely on 'reductionist' methodologies/tools with either single dimension variables, indicators or standards, composite indexes, or 'simple' aggregate metrics (Brunori et al., 2016; Kirwan, Maye & Brunori, 2017). De Ridder et al. (2007) classifies these potential approaches to developing ethical assessment mechanisms as **tools**: e.g., accounting tools, analysis tools, cost-benefit and cost-effectiveness physical analysis tools, multicriteria analysis tools, participatory tools, scenario analysis tools, the use of indicator datasets, and **models or frameworks**. Brunori et al., (2016) build on this differentiation between tools and frameworks stating that tools are the analytical techniques used within wider frameworks which contain a series of prescribed procedures that form the stages of assessment. This suggests that **ethical assessment tools** can be part of a wider construct, **the ethical framework**, where the series of steps in the overarching process of undertaking ethical deliberation are defined. In summary, frameworks, go beyond reductionist indexes or tools. Instead, frameworks embody transparent processes and procedures to provide more holistic insight rather than reducing ethical deliberations to a purely quantitative assessment (Mayer, 2008). This means that the governance and assessment process associated with ethical deliberation can be structured into a series of predetermined steps or activities understood by all stakeholders. As a result, there needs to be a greater degree of transparency as to the outcomes derived, more so than using reductionist numerical data to support comparisons or to demonstrate compliance (e.g., carbon footprint calculations) or using aggregated indexes to demonstrate performance across a range of sustainability metrics in a single number.

A governance architecture is the 'meta-level of governance' (Biermann, Pattberg, Van Asselt & Zelli, 2009; Zelli, 2011). Governance architectures encompass institutions, organisations, regimes, associated normative standards (principles, procedures) and regulations (Zelli, 2011). The term architecture has been used in the literature to consider data governance and the development of data trusts (O'Hara, 2019); artificial intelligence (AI) (Schmitt, 2022); use of robotics (O'Meara, 2011) and more widely e.g. with regard to trade and the protection of the environment (Biermann, Pattberg, Van Asselt & Zelli, 2009). Schmitt (2022) differentiates firstly, between the governance landscape which encompasses multiple initiatives by actors seeking to develop discrete as well as integrated governance structures, and secondly, the governance architecture itself developed through existing and emergent governance regimes.

Food supply chains are established, rules-driven and dynamic regimes existing across different empirical scales and practices within a centralised system that is mediated or reinforced by consumer and producer behaviour (Smith, Stirling & Berkhout, 2005). One example would be the Parmiguano Reggiano PDO cheese supply chain, where there is an existing regime and associated governance structures due to its status as a provenance related food. Lavelli and Beccali (2022) propose that a technology based distributed ledger technology (DLT) and internet of things (IoT) solution could collect, store, integrate and communicate data from multiple stakeholders and multiple stages of the supply chain. The modelling of the smart solution could encompass data collection, information from third party certification and producer groups and through data analysis, pattern recognition and predictive tools create a smart, governance regime. However, reflexive processes are still required at the governance landscape level to address issues such as extant culture, power dynamics, and the emerging socio-cultural framing (equity, fairness, moral hazard and so on) that impacts the adoption of such solutions.

A regime is the assemblage of structure (institutional and physical setting), culture (prevailing perspective), and practices (rules, routines, and habits) (Rotmans & Loorbach, 2009). Regimes can be described as sets of implicit or explicit principles (beliefs of fact and causation, correctness), norms (standards), rules (prescriptions for what actions can be taken), and decision-making procedures that implement collective actors' choice (Krasner, 1982). Dynamic regimes self-organise and when new feedback mechanisms emerge then a new regime is formed (Mayer, 2008).

The contemporary role of instrumental normative performance standards in food supply chains is thus a form of rigid, unreflective and unreflexive governance (Leonard & Lidskog, 2021). Unreflexive governance sets specific performance standards, or a list of criteria, in order to organise and control specific regimes of practice (Spence & Rinaldi, 2014). Instrumental decision-making is essential when seeking to ensure regulatory compliance or where decision-making is based on a binary (legal/illegal; compliant/non-compliant) situation. However, such instrumental regimes of practice lack feedback mechanisms that support the revision of goals, outcomes or targets and do not address the unintended consequences of actions (Kirwan, Maye & Brunori, 2017). Further, existing and emergent power dynamics play a strong role in regimes and governance structures (Dean, 2009) and can drive political tactics, the status quo, even inertia, and as a result the formation of coalitions via processes that lead to regime resistance (Geels, 2004). Regime resistance, as a concept, reflects the activities and structures which prevent a regime from transitioning even when socio-economic and environmental drivers promote the need for change. Indeed, Stuart & Worosz (2012) assert that anti-reflexivity pressures in food supply chains promote 'business as usual' scenarios and prevent adaptive, agile, progressive reform i.e. they entrench inertia and existing regimes.

Existing approaches to ethical assessment, based on individual, organisational or societal framing can be driven by binary thinking leading to the positioning of food supply related dichotomies such as good/bad, organic/conventional, urban/rural, intensive/extensive, or technology-driven/human driven whereas reflexivity can create a more holistic and less contested discourse (Sonnino, Marsden & Moragues-Faus, 2016; Muhammad, Stokes, Morgan and Manning, 2022). Reflection is a goal-oriented activity focused on questioning, evaluating, rethinking and improving practice. Alternatively, being reflexive is informed by reflection and is an ongoing, critical iterative process of engaging with a given situation or context and repeatedly challenging the socio-cultural influences, then following these processes articulating and framing the situation of interest (Barrett, Kajamaa & Johnston, 2020). In other words, reflection can initiate thought processes that 'look at' a given activity or situation. Reflection is 'those intellectual and affective activities in which individuals engage to explore their experience in order for new understandings and appreciation' (Boud, Keogh & Walker, 1985, p. 19). Reflection considers what has happened, what worked/did not work or what went well or did not, but the process is separate and discrete and not part of the activity. Reflexivity, in contrast, requires those undertaking ethical deliberation to reflect on, or consider carefully, the potential decisions that can be made, or not made and the actions that can be taken/not taken and the potential impact prior to taking a decision or any action being implemented (Martin, 2006). This means that reflexivity is part of the active process of deliberation from anticipating, reflecting, and engaging before, during and after, and when acting upon decisions. Reflexivity promotes food system transition through "holistic re-evaluation of [existing] systems and a willingness to make substantial changes in an industrial organisation" (Stuart & Worosz, 2012, p. 288). In summary, ethical deliberation is complex, and whilst reductionist tools and instrumentally driven decision-making may be used in contemporary supply chains: the reframing of 'business as usual' needs stronger grounding. Thus, it is critical to understand the relative strengths, weaknesses and biases of influence when using reductionist tools, indicators and metrics and also how the methodologies employed in the development of assessment tools or within models and frameworks will impact on the efficacy of their use (Mayer, 2008).

Using the concept of reflexive governance, this paper aims to critique existing reflective food-related ethical assessment tools and proposes the structural elements required to go further and develop reflexive governance architectures which address the sharing of data, and the use of AI and machine learning in food supply chains. The need for this research is firstly that the two literatures on food supply chain related ethics and data ethics and the ethics associated with data use have not been brought together previously in an integrated review of the literatures. Secondly, the use of technology such as AI, machine learning and big data informed algorithms can be opaque and ethical implications of their use can be difficult to determine (Hannah-Moffatt, 2019), and if harm is caused by use of an algorithm, e.g. an environmental, health and safety or a food safety incident, it can be difficult to trace the source of the problem and also to identify who is responsible (Mittelstadt et al., 2016). This means scientific enquiry into the potential governance structures that could be applied to address these concerns is of interest.

Options for further development of contemporary ethical assessment practices to move from instrumental to reflective and then reflexive approaches are examined and this informs the evaluation of the embedding of reflexive governance in food supply chains with specific focus on data sharing, the use of AI and machine learning. The structure of the rest of the paper is as follows: Section 1 introduces the research and Section 2 positions ethical considerations in the context of the food supply chain presenting definitions for ethical aspects and ethical outcomes, and ethical focus on decision-making and consequences. Section 3 critiques the ethical implications of data sharing and technology use within food supply chains and the need for ethical deliberation. Section 4 critiques existing approaches to ethical deliberation and ethical assessment associated with food supply chains and food systems and Section 5 provides concluding thoughts and opportunities for future research on developing reflexive governance frameworks with specific emphasis on data sharing, use of AI and machine learning.

2. Ethical considerations in the food supply chain

The ethical aspects and impacts associated with growing, harvesting and processing food can produce positive, neutral or negative intended, or unintended, outcomes in a food system or within a specific supply chain context. The ethical aspects of food supply chains and the drive for sustainability remains implicitly embedded within the triple bottom line (economic, social and environmental aspects) and often is articulated in technical and normative aspects of sustainability rather than being explicitly defined (Amantova-Salmane, 2015). Schlaile et al., (2017) differentiate between descriptive, normative and prescriptive aspects: *descriptive aspects* associated with describing and providing boundaries to the issue; *prescriptive aspects* where there is received wisdom on what should or must be done, and *normative aspects* which can encompass prescriptive aspects, but are also contested by different actors with alternative normative values when they consider what ethical, or sustainable 'looks like,' for example differentiating between standard, good and excellent animal welfare (Muhammad, Stokes, Morgans, & Manning, 2022). In summary, normative ethics describe how things ought to be and inform the development of ‘the set of rules that govern human conduct.’ (Dignum, 2019, p.37).

Normative ethics are favoured in market orientated food supply chains. Rather than describing values, beliefs or norms that influence behaviour (descriptive ethics), normative ethics evaluate behaviour by “appealing to standards or norms that are independent of custom” i.e. normative standards prescribe standards of what ought to be (Fischer, 2004, p. 398). Normative ethics are defined in prescriptive, compliance-based market driven food supply chain standards, e.g., the GLOBALGAP suite of standards, that encompass rules and protocols for right or proper conduct based on a moral evaluation of how people ought to act (Manning, 2020). Indeed, the use of food supply chain standards, audits and third-party verification may actually disguise an opaque, power-mediated, politicised, isomorphic, market-based agenda to drive conformity and reduce transaction cost through what are often promoted as objective assessment tools, indices and metrics (Lebaron & Lister, 2015; Manning, 2020).

Framing develops through communication and discourse between different spheres, actors and groups and as discursive coalitions unfold with regard to an ethical issue (Kirwan, Maye, & Brunori, 2017). Ethical deliberation places existing activities in a given context and can drive transition in supply chains and wider food systems through differentiated, evolving “frames of reference” (Kirwan, Maye & Brunori, 2017), such as the Sustainable Development Goals or SDGs (Bandari et al. 2022). Ethical assessment tools have been used firstly, as process tools to assess and determine ethical priorities and secondly, as mechanisms to support ethical decision-making. It is important to differentiate between the use of an ethical assessment tool (called frameworks by some literature) to guide, support assessment and prioritisation of ethical aspects; the context associated with specific ethical issues, and the use of a ‘framework’ in its wider sense for the provision of theoretical, conceptual or governance structures to inform ethical decision-making and rationalisation of intended and potentially unintended consequences or outcomes of a specific decision.

The duality of the use of the term framework, and the multiple uses in the literature (e.g. from an academic, industry or societal perspective) creates a challenge in terms of developing a narrative and so three descriptions are used herein, firstly, *data governance frameworks* (see Brewer et al., 2021), secondly *ethical aspects assessment frameworks* (see Mepham, 2010; Höglund, 2020) and thirdly *ethical governance frameworks* (see Voss & Kemp, 2006; Beranger 2018). Each framework contains governance structures which are developed to ensure ethical aspects, ethical concerns and the role of individuals and organisations are considered through the application of ethical theory, but they vary in the degree of reflexivity that is embedded in their development and use. To differentiate more clearly, reflexive, ethical governance frameworks are described as *reflexive governance architectures*. The vocabulary used in the literature to explore the context of ethical aspects and ethical outcomes, otherwise described as targets, objectives, or impacts as with the multi-level structure of the SDGs and associated targets, is critiqued to substantiate the role of reflexive governance architectures.

2.1 Ethical aspects

From the environmental perspective and considering the terms used in normative standards such as EN ISO 14001:2015, an *aspect* is an "element of an organisation's activities or products or services that interacts or can interact with the environment" and an *impact* is a "change to the environment, whether adverse or beneficial, wholly or partially resulting from an organisation's environmental aspects." Therefore, an organisation can interact positively or negatively with the environment through its activities, products or services and this interaction is the environmental aspect. Höglund (2020) when considering ethical aspects differentiates between those that relate to production and nature and those that relate to humans and consumption. Manning, Baines & Chadd (2006, p.366) define ethical aspects of food production as “the ethical considerations which relate to the organisation’s activities, products or services.” These include, but are not limited to: food sourcing; resource management and the impact on the environment; inter-organisational partnerships within the supply chain; intra-organisational partnerships, working conditions, health and safety, and training; ethical norms of business customers, third parties and consumers; aspects of food safety, nutritional content, quality and affordability; livestock health, welfare and husbandry standards and the use of technology, and in this case, AI and machine learning.

AI based applications can be used to improve safety, product quality, diagnostic ability and problem-solving capability, production efficiency and resource use (Kumar, Kharkwal, Kohli, & Choudhary, 2016). Ethical aspects can be considered in terms of technology and engineering design (Mulvenna, Boger & Bond, 2017); human-technology interaction (Korn, 2017) and design and adoption of AI (Kumar, Kharkwal, Kohli, & Choudhary, 2016); for example, the use of drones for spraying and self-steer tractors (Ryan, 2022), and AI and robots for agri-food (van der Burg et al., 2022). Rogozea (2009) identifies a number of ethical aspects of AI adoption, albeit mainly considered in a biomedical context. These include confidentiality, responsibility, rights, respect, informed consent, standards, malpractice, and the modification of interactions between people, power dynamics and accessibility. An additional consideration is the replacement of work roles previously undertaken by humans, reflecting the aspects of power being given to technological applications (Kumar, Kharkwal, Kohli & Choudhary, 2016). Other studies cite aspects such as fairness (as opposed to bias), preservation of human autonomy (agency), technical robustness and safety, prevention of harm, explicability, accuracy, accountability, data governance and privacy, transparency, confidentiality, discrimination, security, unintended uses of data and right to know or not to know results, diversity, environmental and societal wellbeing (Brall, Schröder-Bäck & Maeckelberghe, 2019; Karimian, Petelos & Evers, 2022). Further ethical aspects of the use of AI are accessibility, auditability, culpability, explainability, interpretability, reliability, responsibility, transparency, and trustworthiness (Friedman & Nissenbaum, 1996; Martin, 2019; Manning et al., 2022). In this respect, Rakowski, Polak and Kowalikova (2021, p. 201) state "Technology is thus not a neutral tool: it has its own value, but at the same time society can determine the direction of its development", for example in the delivery of the SDGs (SDGs, 2022). van der Burg et al. (2022) in their work on the ethical aspects of the application of AI in agri-food systems cite the following aspects that need to be considered: moral agency, moral status, responsibility and liability, the value of robot-human relations and other sentient beings such as livestock, aspects of human employment and labour, benefits of AI robot use and to whom, the framing of good farming, environmental sustainability, data sharing and the distribution of power.

Manning et al., (2022) note that whilst there are different perspectives and nuances on where a specific use of AI in the food system is positioned on the socio-technological determinism spectrum, (where people or technology can have the primary role in decision-making), the ethical aspects of the use of AI will vary from application to application. This means that ethical aspects such as explainability or trustworthiness of AI will have different framing as in different contexts, e.g., with a robotic milking machine or a mobile app for food allergen information, what it is to be explainable or trustworthy will vary and be appropriate to context of use. Concepts such as animal welfare or worker welfare will influence perceptions of the ethical use of AI technology. This means ethical deliberation on human-technology-crop and human-technology-animal interactions may not reflect the same ethical aspects, for example, the use of an AI application in crop production compared with the monitoring and determination of animal welfare indicators.

2.2 Ethical impacts

Technology can mediate an organisation's socio-economic and environmental performance and the organisation's *ethical impact* through improved efficiencies in enterprise resource planning, logistics and transport management systems (Agyabeng-Mensah, Ahenkorah & Korsah, 2019). Manning, Baines & Chadd (2006, p.368) describe an ethical impact as "any ethical influence whether adverse or beneficial, totally or partly resulting from an organisation's activities, products or services." Ethical impacts, outcomes or consequences can be intended or unintended, singular or plural. Plural ethical impacts can result from activities, products or services acting as a catalyst to deliver multiple impacts and outcomes making reflexive ethical deliberation difficult to achieve in practice if ethical impacts are considered individually, or in isolation. Examples of ethical impacts include positive and intended impacts such as better worker conditions, improved animal welfare outcomes or reduced crop protection product use or negative and unintended impacts such as a pollution incident, an animal welfare problem or a food safety incident.

2.3 Ethical objectives, targets and outcomes

Ethical objectives and targets are intended ethical outcomes. Ethical targets are "detailed performance target[s]… that arise from the ethical objectives and which need to be defined and complied with in order to achieve those objectives." (Manning, Baines & Chadd, 2006, p. 368). Ethical objectives are "an overall ethical goal, consistent with the corporate social responsibility policy that an organisation sets itself to achieve" (Manning, Baines & Chadd, 2006, p. 368). The SDGs could therefore be considered as an appropriate (widely known and authoritative) frame of reference of desirable ethical goals or outcomes and their associated targets which help orient processes of ethical deliberation to determine what sustainability 'looks like' in practice.

2.4 Consequentialism, an ethical theory

Consequentialism considers the consequences of human actions and the extent to which desired results are achieved, and undesired results are not (Robertson & Fadil, 1999). Patel (2020) describes consequentialism as considering ethics and morality through the consequences, outcomes or effects of decisions or actions taken. Consequentialism positions that the ‘morally right action is the one with the best overall consequences’ (Dignum, 2019, p.37). *Consequentialist ethics* (or teleological ethics) focus on whether the ethical implications of the outcome or consequences are more important than the ethics associated with the action, whilst, *rule-based ethics* (principle-based, duty based or deontological) focus on consideration of the action itself and whether it was ethical, based on prescribed rules, laws or obligations i.e. was what was done good or bad, right or wrong (Dignum, 2019; Patel, 2020). Mepham (2000) explains this dichotomy of approach as the difference between ethics being identified as a result of assessing costs and benefits, a utilitarian approach, or alternatively focusing on ‘rights and duties.’ There is a third approach in ethical theory, *virtue ethics*, which associates concepts such as fairness and justice with an activity, action or outcome, introducing notions of the *good consumer* who acts via a process of food citizenship (De Tavernier, 2012; Del Savio & Schmietow, 2013; Mepham, 2000) and by inference the good farmer, the good processor and the good retailer.

2.5 Virtue ethics and ethical agency

Virtue ethics focuses on the character of the individual rather than the action or the consequence and what a ‘good’ person would do (Dignum, 2019). Driessen and Heutinck (2015) consider the ‘good farmer’ in the context of the interaction between the dairy cow, the farmer and the technology, in this case autonomous milking machines where ethical norms and principles evolve with the introduction of technology and what is then perceived as good in terms of the good farmer, good cows, a good life and a good robot. How the good robot-good farmer collaboration is defined is important, but there is less research on this interaction in agri-food supply chains compared to, for example, in care or learning environments (Ryan, van der Burg and Bogaardt, 2021, van der Burg et al., 2022).

3. Data and technology related ethics

The Open Data Institute (ODI, 2022, p.1) define data ethics as "a branch of ethics that evaluates data practices with the potential to adversely impact on people and society, in data collection, sharing and use." Thus, the concept of data ethics reflects appropriate actions related to how data is collected, maintained, used and shared and the ethical impact on individuals, communities and society. Data ethics should be addressed during data stewarding, when either information is created from the data or actions are driven by the interpretation of data (ODI, 2022). Ethical questions associated with data can be characterised as factors that relate to the data itself i.e., *ethics of data*; the ethics associated with results generated by an algorithm (*ethics of algorithms*); and how those results are used in practice (*ethics of practice*)**,** see Beranger (2018). Algorithms can be developed to profile, classify, provide information to support decision-making, and understand and interact with the immediate and more extended environment. Their design can mean algorithms are value-laden, biased and can discriminate (Mittelstadt et al., 2016). Mittelstadt et al., (2016) highlight six types of ethical concerns that arise with the use of algorithms. Three concerns relate to the episteme (type or level of evidence): inconclusive evidence, inscrutable evidence, and misguided evidence. *Inconclusive evidence* is where statistical analysis does not provide actionable insight so although correlation can be shown, causality cannot be proven i.e. patterns may suggest there are associations or relationships, but causation cannot be demonstrated in practice (Tsamados et al., 2021). *Inscrutable evidence* suggests that the data available lacks transparency, explainability, or interpretability and does not allow the algorithm to reach a conclusion, meaning the data may come from a dubious source, or be unverifiable. *Misguided evidence* (otherwise known as garbage in-garbage out) means conclusions are only as reliable as the data used and the level of neutrality of the process used (Tsamados et al., 2021). These three concerns focus on the quality of evidence and the degree to which it can inform an action, and also mediate the degree of trust between agents sharing information and these concerns inform notions of trustworthiness in the data-technology-human(s) interaction.

Three normative concerns are presented by Mittelstadt et al., (2016). Firstly, the use of the algorithm may lead to *unfair outcomes* as a result of the decision, action or event. For example, an action can be perceived as unfair if it is believed to be discriminatory to an individual or a group. Secondly, some actions or activities that use algorithms can lead to *transformative effects* by changing contemporary norms and modifying what is 'said to be' the accepted standard, guideline, code or appropriate forms of association. Examples include the development of algorithms to support personalised diets or personalised medicine. It is important to recognise that algorithm used to determine patterns in data-based applications can replace more qualitative approaches that allow categorisation of trends or themes. This algorithm driven process can lead to reductionism and abstraction and as a result the richness or nuance associated with the data and the information that can be derived from it can be lost. This lack of a holistic approach to data analysis means that the potential to gain insight into social phenomenon when using algorithms to recognise patterns in quantitative data, or the use of historic training datasets, does not necessarily highlight emergent human perceptions, attitudes or behaviour (Mehozay & Fisher, 2019). The third normative concern is *traceability* i.e. the harm caused by an algorithm can be difficult to trace and also to identify who is responsible especially as in ethical deliberation the cause and the responsibility for a potential or actual harm needs to be traced (Mittelstadt et al., 2016).

There are many ethical considerations that AI shares with other technology including: the complexity of the systems that the applications are used in; notions of responsibility; perceptions of what transparency is in the context of technology use; the ethical aspects of machines replacing humans and the difficulty in predicting the ethical impacts that can arise in the future associated with the context and/or use of the technology (Boddington, 2017). In terms of virtuous or good technology, beneficial AI is said to refer to AI that is safe and beneficial for society (Baum, 2017). In order for autonomous machines to be ethical agents in themselves, the AI must be designed so that:

- It is possible to choose between different actions and outcomes,
- At least one option (action/outcome) must be socially beneficial so the agent is able to mediate notions of harm (but what it is to be socially beneficial may be contested by different stakeholders), and
- The agent recognises socially beneficial actions/outcomes and is able to take a decision because it is the right ethical option. This level of ethical agency requires an element of automated analysis to take place as previous decisions and their outcomes have to be evaluated in order to inform better future decisions (Dignum, 2019).

Malle (2016) considers the difference between moral competence and moral agency in the context of robots, see also van der Burg et al., 2022. Moral competence, in terms of the capabilities of a robot, Malle argues, has five aspects: a moral vocabulary, moral cognition and affect, moral decision-making and action, moral communication and a system of norms. Malle and Scheutz (2017) reflect on this further stating that in human-technology interaction, the moral competence of the robot needs to be considered alongside the moral competence of the human(s) who design, and use the robots, and by extension the AI applications. Thus, human moral competence will impact on the moral competence of the robot. Indeed, Malle, Scheutz, Forlizzi & Voiklis (2016, p.125) argue there is an asymmetry in how humans consider other humans and robots when they take action to address a moral dilemma namely "that people blame robots more for inaction than action but blame humans more for action than inaction in the identical dilemma.” Moral agency, the “contextualised normative judgment and action to respond to the demands and contingencies of the present” (Antadze & McGowan, 2017, p.2), is of importance here. Whilst humans have the ability to demonstrate moral agency, determining what moral agency is in the context of the use of robots in the food supply chain (see van der Burg et al., 2022) requires further exploration.

The next section considers the use of compliance based, reflective and reflexive approaches with particular emphasis on AI and machine learning. It is positioned here that ethical assessment is only one element of undertaking reflexive ethical deliberation.

4. Ethical assessment and reflexive ethical deliberation

Based on the premise that no individual actor has the absolute moral truth, when considering ethical aspects and outcomes, collective ethical deliberation is essential, especially where an action involves multiple actors (Gracia, 2003). There is dialogic openness and knowledge creation, when the deliberation process compares potential courses of action, identifies which are morally justified and which have the strongest moral underpinning. Such reasoning is not based on quantification, but on argumentation where: “quantification has, as its goal, to resolve the question rationally and completely; whilst the only goal of argumentation is to be “reasonable,” and therefore open-ended” (Garcia 2003, p. 227). Whilst reflection encompasses learning *through* experience, a reflexive approach embraces learning *in* experience. Reflection is a cognitive activity, whereas reflexivity is a dialogic, practical and relational activity. Reflection involves giving order to situations, whereas practical reflexivity accepts multiplicity, circularity and unsettling conventional practices and is grounded in a constructionist and deconstructionist view of the world (Cunliffe & Easterby-Smith, 2004; Pässilä, Oikarinen & Harmaakorpi, 2015). In summary, reflection focuses on questioning, evaluating, and rethinking of existing experience(s) to improve practices and gain new understanding, and in turn informs being reflexive (Boud, Keogh & Walker, 1985; Barrett, Kajamaa & Johnston, 2020). Both of these processes are essential for ethical assessment and the building and implementation of reflexive governance architectures.

4.1 Reflexive governance

Reflexive governance drives the continuous, intentional assessment of objectives, the means and pathways used to consider current practices and the need for restructuring particular regimes of practice (Kirwan, Maye & Brunori, 2017). As a result, reflexive governance is a mechanism to evaluate and reframe relations between multiple actors and enable civic participation with regulators (Marsden, 2016). Examples of reflexive governance include the processes that have been developed to produce national and regional food strategies, such as the use of citizens assemblies, and supply chain transition strategies such as net zero food supply agendas (Marsden, 2013; 2016). Production-consumption relationships are worthy of further consideration in the context of developing reflexive governance structures that combine the use of ethical assessment tools within a wider governance architecture allowing for holistic ethical deliberation. For example, the use of AI and machine-learning based technology and applications can reduce food loss and food waste. An example is the IoT based system proposed by Gayathri et al., (2021), where such approaches enable the more efficient use of resources (natural, physical, human, financial, social capital), whilst ensuring that ethical aspects and outcomes are addressed both with regard to the activities themselves and the ethical use of the data collected. However, to be truly effective and encompassing, reflexive governance structures rely upon multidisciplinary and interdisciplinary scientific knowledge and expertise (Marsden, 2016).

Reflexive governance should entail institutional and procedural arrangements that frame multiple episteme, cognitive and normative beliefs, alternative understandings and viewpoints, governance levels, and problem-solving approaches (Marsden, 2013). Sonnino, Marsden and

Moragues-Faus (2016, p.487) describe these reflexive governance architectures as an "active and progressive canvas for reassembling resources and human efficiencies around more effective production–consumption relations." Calls in the literature for wider adoption of reflexive governance link to sustainable development (Voss, Bauknecht & Kemp, 2006), the SDGs, meeting net zero ambitions, and processes for technology adoption and innovation (Lindner et al., 2016). However, others caution that governance 'in' and governance 'of' a given construct are quite different approaches and need to be considered discretely (Rip, 2006). In particular that: "unintended and often unexpected effects [outcomes] occur because actors do not take the overall socio-technical dynamics into account" (Rip & Groen, 2001, p.21)

Herein, it has been positioned that ethical framing, via the use of reflexive governance architectures can inform contemporary and future food supply chain governance structures. This is of particular interest as new practices and technologies such as AI are adopted and embedded in common practice in food production. van Bruxvoort & van Keulen (2021, p.1). state that in considering the use of AI in its wider social context it is important to view "the algorithm embedded in an organisation with infrastructure, rules, and procedures as one 'to-be-designed system'." With the context of the use of AI and machine learning in food supply chains, the relevance of reflexive governance is contextualised in terms of "anticipation, reflectivity, inclusion and responsiveness' aspects of responsible (research and) innovation (RRI) (see Stilgoe, Owen & Macnaghten, 2013; Gianni & Goujon, 2018; Craigon et al., 2023; for a wider discussion on this theme). Indeed, Lindner et al., (2016, p. 14) state:

> "The implication for reflexive governance is quite strong: innovation is a social phenomenon, determined not just by the scientific and empirical knowledge in society, but also by the views and needs of social actors. Governance processes can therefore play a role in determining and realising the direction of innovation, as can the other actors involved in technological development."

So how reflexive are contemporary ethical assessment approaches in food supply chains?

4.2 Ethical matrices

Ethical matrices are a tool to support ethical reflection. Ethical matrices are pluralistic, addressing multiple stakeholder interests and ethical principles (Kaiser & Forsberg, 2001). The seminal matrix on which many of these 3 x 4 matrices are based is the Mepham (2000) Food Ethics Matrix (Figure 1). This matrix includes ethical principles of respect for wellbeing (health and welfare), autonomy (freedom and choice) and justice (fairness) in the context of producers, consumers, and the entity involved (organism or fauna and flora). Technology use is not an explicit aspect addressed in the matrix, more its use can be assessed in terms of the elements in the matrix. The Food Ethics Council Ethical Matrix (Figure 2) is a framework that is based on the three ethical principles: respect for wellbeing, for autonomy, and for justice as an assessment tool for common morality found in the Mepham (2000) version.

Take in Figures 1 and 2

Kaiser and Forsberg (2001) too, use a matrix approach to identify ethical aspects for a wide range of stakeholders, replacing autonomy with dignity in their matrix, arguing that this reflects a principles-based ethics approach, or *principlism*. Principlism has been described as a form of ethical reflection which is based on four principles: *benevolence*, that the result of technology use or implementation is positive; *non-maleficence* that the use or implementation of the technology will do no harm; *autonomy/dignity* namely that the use or existence of the technology will not limit or compromise affected party's freedom; and *justice*, i.e. the use or outcomes of using the technology are deemed fair (Beauchamp & Childress, 2012; Thompson et al., 2021). Thompson et al., (2021) assert that the matrices are a modified principlist tool where the four principles form elements of the matrix, or a rubric to inform collaborative reflection and discussion.

Mepham (2010) differentiates between a specified principles matrix that captures the ethical aspects that policy decisions may wish to respect (Figure 1) and a policy objectives matrix that, rather than defining ethical aspects, highlights policy proposals that relate to those aspects. This dual approach of applying a specified principles matrix and a policy objectives matrix stops short of defining ethical outcomes but does provide a tool to identify a policy solution for a given ethical aspect. The matrices have been used for decades in the food supply chain with little revision. However, Höglund, (2020) in the proposed ethical matrix describes the four groups in previous matrices in more simple terms namely: producer, consumer, treated organism and biota, as 'affected parties' where three of these relate to the production of food, i.e., the action or activity, and the other affected party relates to the consumption of food and the decision-making that is associated with the consumer (Figure 3). Höglund positions that there are three reflective questions that need to be asked when using the matrix as an assessment tool:

- What/who are the affected parties in a given situation?
- What values are at stake for these affected parties and where is there mutual alignment or potential value conflict?
- Can the value conflicts be addressed by considering from the ethical perspective of duty [what ought to be done], consequences [what will happen if the action is taken], virtue [what would a good person do] or care [attending and meeting the needs of others]?

This demonstrates that Höglund proposes that ethical aspects and ethical impacts of actions, decisions and practices can be assessed using a matrix approach providing the assessment is guided by a set of questions.

Take in Figure 3

Reflexivity, and in particular ethical reflexivity, acknowledges that humans constantly and consciously reflect on normative judgments and ethical principles in a given context to then inform decision-making, deliberation and intuition usually on a case-by-case basis (Beever & Brightman, 2016). Thus, the ethical matrix approach synthesizes deontological principles with utilitarian values to inform the mapping of ethical aspects and potentially informs reflection on impact(s) in a given context (Mepham 2010; Korthals, 2015). Korthals (2015) suggests that tools, such as matrices, allow the users to approach ethics in a principles-based, value orientated approach, but these tools are limited in terms of considering complexity so it is a challenge not to be selective and consider aspects individually rather than in a broader holistic, systemic view. Further, a drawback of using an ethical matrix is where there is a strong dependence on past experience as part of the reflection process so that decision outputs can be influenced by persuasive confirmation bias (Thompson et al., 2021). From their structural arrangement, these matrices inform reflectivity, but to be reflexive requires an additional reflexive deliberation process.

4.3 Multi-criteria performance matrix

Kirwan, Maye and Brunori (2017) in their work developed a 5x4 matrix they propose as a multi-criteria performance matrix (Figure 4) that uses five dimensions (economic, social, environmental, health and ethical) and four spheres of debate and communication (public, market, scientific and policy) to consider ethical aspects and impacts in a given context. They describe ethical aspects as ethical attributes that can be clustered under themes (the dimensions). Further, they suggest considering these ethical attributes in a 'reflexive governance framework' where the framework informs deliberation and decision-making i.e., they proposed a two-stage approach asserting that:

> "In adopting a reflexive governance approach, firms are able to anticipate unintended (and unwanted) consequences of supply chain operations and adapt their regimes of practice accordingly, before they become unsustainable" (Kirwan, Maye & Brunori, 2017, p. 30).

Take in Figure 4

If the individuals using them have the appropriate skills in reflexivity, the three matrices and this framework can enable iterative participatory goal formation and drive interactive strategy development as highlighted by Mepham (2010). The SDGs, for example could play an orienting role in the process of principle development, support iterative participatory goal formation, and drive interactive strategy development. However, there are no inbuilt reflexivity processes within the matrix-based tools and if the team using the matrix do not possess reflexivity skills, the process of utilising the matrices could stop at reflection only. Additional bolt-on processes could support the adaptivity of strategies and institutions to address complexity, uncertainty or ambiguity and provide a functional process to anticipate long term systemic effects of supply chain strategies, especially in the context here of the application of AI and machine learning.

4.4 Reflexive governance typologies

Critiquing the elements of existing ethical matrices as tools for ethical assessment of the use of AI and machine learning in food supply chains, Beranger (2018) embeds a supplementary deliberation phase and develops a reflexive ethical governance architecture typology with five key dimensions:

1. Assessing the technical aspects of data;
2. Assessing the ethical aspects of the use of AI and machine learning in food supply chains;
3. Assessing the ethical aspects of the practice itself that uses AI and machine learning (e.g. milking cows with robots, or picking cabbages with robots);

4. Determining the ethical impacts of practice, and
5. Developing reflexive governance processes that act as a governance architecture around the ethical deliberation process.

Table 1 draws together these five dimensions and integrates the work of Beranger (2018) to consider the characteristics of each dimension in more detail. It is important to note that some characteristics sit in more than one dimension e.g. accountability is assessed within the ethical aspects of practice, and within ethical impacts of practice and developing reflexive governance.

Take in Table 1

The five dimensions are further informed by Voss and Kemp's (2006) five principles to guide the design and implementation of reflexive governance in practice, as reviewed by Kastrinos & Weber, (2020). These principles are of value in developing a process that enables:

- **Integrated (transdisciplinary) knowledge production**, that informs the creation of multiple perspectives for addressing complex and co-evolving issues.
- **Adaptivity of strategies and institutions** driven by the degree and depth of drawing monitoring systems and processes to address uncertainty and ambiguity with regard to values, problem perceptions and possible solutions.
- **Ability to anticipate** the long-term systemic effects of supply chain strategies, considering the complex dynamics that can occur.
- **Iterative participatory goal formulation**, to consider potential value trade-offs as well as potential synergies between different actors' and stakeholders,' and
- **Interactive strategy development**, that can consider the required resources and (potentially conflicting) interests of different stakeholders from a range of areas of social, economic and political activity.

Using the five principles developed by Voss and Kemp (2006) as a guide, the matrices, depending on the abilities of the individuals using them, can integrate transdisciplinary knowledge production that focuses on ethical aspects of the use of AI but not necessarily technical aspects of data, or ethical aspects of the design or use of AI and machine learning. As the use of technologies such as self-driving tractors, robots and AI informed applications, decision-support systems and software (Ryan, 2022) increases these five principles become more important in terms of their embedding in ethical assessments and reflexive governance architectures. Figure 5 presents an integration of the work of Voss and Kemp to compare and contrast the ethical assessment tools with regard to their ability to inform reflexive governance. The tools are of value to inform integrating transdisciplinary knowledge production depending on the skillset of the team undertaking the assessment (represented as a ✓ in Figure 5), but unless the team have reflexive skills between them the tools alone will not enable iterative participatory goal formation, drive interactive strategy development nor act as a catalyst to improve adaptability of strategies and institutions to address uncertainty or ambiguity.

Take in Figure 5

Spence and Rinaldi (2014), based on the work of Dean (2009), suggest four dimensions as a connected and differentiated lens of enquiry when considering governance: fields of visibility analytic, techne analytic, episteme analytic, and the identity formation analytic. These are now presented in turn with a focus on reflexive ethical consideration of the use of AI and machine learning in food supply chains.

The *fields of visibility of governance* reflect the visible objects or subjects of governance. These include matrices, charts, and other artefacts of analysis that promote transparency and openness. However, opacity may exist as certain ethical aspects may be considered outside of the glare of customers, consumers and others. The ownership of artefacts and the meetings, and other interactions in which they are used will influence the power dynamics within governance structures (Spence & Rinaldi, 2014).

The *techne of governance* is the collection of technical means to demonstrate compliance with visible values, espoused beliefs and ideals (Spence & Rinaldi, 2014). These technical aspects include standards, tools and frameworks and training programmes and skills development and individual and collective vocabulary, with associated meanings. Standards in this context are the defined criteria or 'sets of rules' that support the classification of a product into a given category (Kirwan, Maye, & Brunori, 2017), or define a way of doing. The techne of governance can include meetings, training, auditing and incentives based on norms defined in frameworks, standards and specifications, promoting a rationale of governance through education, normalisation, regulation and delivering to market needs (Spence & Rinaldi, 2014).

The *episteme of governance* refers to the trust mechanisms, discourses and rhetoric of value, expertise, language thinking, questioning and derived meaning associated with practices of governing including routines, rituals and norms for conduct of actors (Dean, 2009). Algorithms are not ethically or morally neutral (Tsamados et al., 2021), so episteme associated with algorithms, can be described as 'a new way of knowing' and how human thoughts, decisions and rationalisations are translated into a technological knowing that "excludes reflexivity, language, and subjectivity from the construction of self" (Mehozay & Fisher, 2019, p. 525). Mehozay and Fisher's work on algorithmic risk analysis, albeit based on criminology, is of value when considering the use of AI and ethical considerations in the food supply chain.

Hannah-Moffat (2019) considers the gap between actuarial risk (assessing risk as a human based on historical data, experience etc.) and algorithmically determined risk when considering social justice and criminal sentencing. The reason for including these sources here is that the food supply chain, especially agriculture, lags behind other sectors in the use of algorithmic risk assessment and algorithmic based decision-making. If a gap persists between the design and operation of algorithms and human understanding of the ethical implications and outcomes that could arise, this could have severe consequences on individuals, communities, even society as a whole (Mittelstadt et al., 2016). Hannah-Moffatt (2019) concludes that the rationalities and techniques of algorithmic risk governance are based on constructs such as probability and patterns within data to then guide policy, but big data informed algorithms are opaque and when considering ethical or moral aspects the algorithms are devoid of social, political and ethical consciousness. The episteme analytic considers the contemporary mechanisms, discourses, language and rhetoric, and capturing the nuances in AI and machine learning, or indeed the training datasets on which they are based, is difficult.

With regard to the *identity formation of governance*, the role of identity is important as it mediates actions, practices and ways of considering self, others, groups, roles and influences implementation of governance structures (Spence & Rinaldi, 2014). It is difficult to capture perceptions of identity or social context in the 'human self' created by algorithms which essentially is an aggregate of multiple data points (Mehozay & Fisher, 2019). Mittelstadt et al., (2016) distinguish between an algorithm as a mathematical construct, the actions and effects the algorithm can initiate when used in a given technology or programme, and then how that technology is configured to undertake a specific task (application). What has been previously described in this paper as the human-technology-plant or human-technology-animal interaction is important here as perceptions of identity, being the farmer, the animal care-giver (Muhammad, Stokes, Morgans, & Manning, 2022), and evolving aspects of identity, can be challenging with concern over rules, weighting and how uncertainty are addressed in what to may appear to users to be an opaque process to either provide evidence for a given outcome and/or to trigger or motivate an action (Mittelstadt et al., 2016). Feher (2021) outline that digital identity reflects the profiles within digital services and, as authentication processes and self-validation become more sophisticated, the human self and the digital self must become more aligned, especially so with regard to responsibility, moral agency and moral competence. The boundaries of personal digital identity management (including control of privacy, rights, responsibilities and freedoms) is an ethical aspect of data use, especially as technologies and the algorithms associated with them change (Feher, 2021).

The four fields of governance visibility analytic, techne analytic, episteme analytic, and the identity formation analytic are central to developing reflexive governance architectures. Marsden (2013, p. 131) argues that such networked reflexive governance frameworks [architectures] can "foster new forms of socio-technical inclusion, coherence and consolidation". This review paper makes a contribution by drawing together this interdisciplinary literature to inform future empirical work on the development of reflexive governance architectures to support the ethical consideration of the use of AI and machine learning in food supply chains.

5. Concluding thoughts

5.1 Governmentality

Governmentality, the role and conduct of governance actors (corporations, senior employees, regulators etc.) and the governed i.e., supply chain partners, workers, customers, consumers (Spence and Rinaldi, 2014) in the problematisation and mitigation of ethical aspects and outcomes is of crucial importance within the architecture of regimes of practice. The architecture involves both collegiate practice (meetings, boards, committees) and people (employees, shareholders, customers, consumers), where the interaction is mediated by systems (control systems, reporting systems and sanction and reward-based systems) see Spence and Rinaldi (2014). Existing power dynamics form a barrier to engaging in meaningful reflexive governance (Marsden, 2013), especially when actors seek to “reconcile the demands of reflexivity (being open, self-critical and creative) with the demands of their existing political world” (Hendriks & Grin, 2007, p.333). Governmentality can drive existing inbuilt biases, both visible and opaque that ‘govern’ food supply chain structures and interactions (Mittelstadt et al., 2016). Without ethical consideration at an early stage, especially if these biases are embedded in training datasets, they can translate into AI and machine learning applications e.g., as determined in recruiting and hiring of staff (see Raghavan, Barocas, Kleinberg & Levy, 2020; Sühr, Hilgard & Lakkaraju, 2021) and in criminal justice (Hannah-Moffat, 2019; Mehozay & Fisher, 2019). Indeed Ryan (2022), suggests more focus needs to be placed on ethical aspects such as explainability, accountability, interpretability, and understandability.

5.2 Trust frameworks

Brewer et al., (2021) describe how governance systems for data exchange are complex, posing ethical challenges especially when they focus on technologies such as AI, and propose ‘data trusts’ as one form of collaborative, participatory, data governance architecture with particular emphasis on ‘trust frameworks.’ A trust framework is developed by a community, supply chain or network on the basis of members having similar goals and objectives. It defines rights and responsibilities, specifies normative standards, policies, processes and procedures in order to consider the level of risk associated with participants and the transactions that are involved (NSTIC, 2011). Temoshok and Abruzzi, (2018, p4) state that a trust framework manages roles, liability and legal issues, uses, shares, protects and secures identity information, and conducts identity management responsibilities agreements, trust and governance through “a set of rules and polices that govern how [members] will operate and interact.” Brewer et al., (2021) propose four distinct elements of a data trust that would be engaged with the use of AI and machine learning in food supply chains. These are

(1) A **governance and legally contractual normative framework** that defines rules, and roles, accountability, responsibility for all members;
(2) A **security and permissioning normative framework** that controls access for members, and security of the data that is shared;
(3) A **knowledge mapping element** which establishes the interoperability of the data trust e.g. manages interfaces, quality control processes and curation standards, and an
(4) An **operational component** where the interactions and processes occur.

Data trusts can include multiple frameworks with different operating functions and also involving different members of the community (NSTIC, 2011). Research for the UK Food Standards Agency has considered the development of food data trusts (FSA, 2021) and the Open Data Institute (2019) has considered food data trusts and their role in reducing food waste.

5.3 Reflexive governance architectures

Hendriks and Grin (2007, p.342) assert that developing reflexive governance architectures enables capacity building and acts as a catalyst that 'encourages actors to scrutinise and reconsider their underlying assumptions, institutional arrangements and practices' (Marsden, 2013). The collection, sharing, exchange and analysis of data is one such example where institutional arrangements and practices, underlying assumptions, rules and norms can develop through the interactions of business-to-business (B2B) or through business-to-consumer (B2C) interaction. Indeed, it is accepted practice that B2B data sharing requires complex governance systems that define and determine aspects such as statutory obligations, confidentiality, data ownership, commercial rights, use and access to data and so forth, and data exchanges that involve personal data (B2C) need to protect obligations to individuals enshrined by regulations such as the United Kingdom's (UK) and the European Union's (EU) General Data Protection Regulation (GDPR, 2018; Brewer et al., 2021).

Five dimensions of ethical reflexive governance have been considered with a particular focus on reflexive ethical governance architectures that consider AI and machine learning, and the typology of technical aspects of data; ethical aspects of AI and machine learning; ethical aspects of the practice being considered; ethical impacts of practice, and the role of reflexive data governance, for example the use of a data trust framework. Using the concept of reflexive governance, this paper has critiqued existing reflective food-related ethical assessment tools and proposed the structural elements required for reflexive governance architectures which address the sharing of data, the use of AI and machine learning in food supply chains. The use of ethical aspects assessment tools within a wider reflexive governance architecture offer the opportunity for further development of contemporary ethical assessment practices to move from instrumental principlism to reflective assessment of ethical aspects and potential outcomes and then informs thinking around emergent reflexive governance approaches that address ethical deliberation in food supply chains.

5.4 Summary

Whilst the integration of the literatures of ethical assessment in the food supply chain and reflexive governance architectures is a strength in this work, to date much work on application of AI and machine learning and developing data trust frameworks is still at the research application and review stage. This is a limitation in terms of the direct application of this research within the industry. However, creating awareness of the difference between reflective and reflexive governance is of value to the industry and can inform contemporary practices so that the current use of ethical assessment tools can be extended to include more collaborative, holistic, reflexive ethical governance. Future research needs to develop the governance typology further, such as the development of a reflexive framework for the development of data trusts in food supply chains. Examining food supply chain scenarios through applying reflexive ethical lenses means the conceptual research herein can be applied, critiqued and can evolve to inform practical approaches, tools, applications and governance frameworks for the food industry.

Acknowledgements

This research augments the Food Standards Agency (FSA) funded work led by the University of Lincoln to create a Data Trust Framework related to food safety (Brewer et al., 2021). The working group that contributed to this paper is joint funded by the Internet of Food Things Network^{+} (Grant Number: EP/R045127/1) and the Artificial Intelligence and Augmented Intelligence for Automated Investigation for Scientific Discovery Network^{+} (AI3SD) (Grant Number: EP/S000356/1).

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Figure. 1. Mepham (2000) Food Ethics Matrix

Respect for	**Wellbeing (Health & welfare)**	**Autonomy (freedom & choice)**	**Justice (fairness)**
Producer	Adequate income and working conditions	Freedom to adopt or not adopt	Fair treatment in trade and law
Consumer	Availability of safe food; acceptability	Consumer choice (e.g. labelling)	Universal affordability of food
Treated Organism	Animal welfare	Behavioural freedom	Intrinsic value
Biota (fauna and flora)	Protection of the biota	Maintenance of biodiversity	Sustainability of biotic populations

Figure 2. The Food Ethics Council Ethical Matrix

Respect for	Wellbeing (Health & welfare)	Autonomy (freedom & choice)	Justice (fairness)
People in the food industry	Income and working conditions	Freedom of action	Fair trade laws and practices
Citizens	Food safety and quality of life	Democratic, informed choice	Availability of affordable food
Farm animals	Animal welfare	Behavioural freedom	Intrinsic value
The living environment	Conservation	Maintenance of biodiversity	Sustainability

Source https://www.foodethicscouncil.org/

Figure 3. Alternative version of the matrix (Höglund, 2020)

Respect for	**Wellbeing (Health & welfare)**	**Autonomy (freedom & choice)**	**Justice (fairness)**
Producer	Income and working conditions	Freedom to adopt or not	Fair treatment
Consumer	Availability, safety	Free choice	Universal affordability
Organism	Animal welfare	Behavioural freedom	Respect for telos
Biota	Conservation of animal and plant life	Maintenance of biodiversity	Sustainability

Figure 4. Multi-criteria performance matrix (Kirwan, Maye & Brunori, 2017)

Dimension/ Sphere	Economic	Social	Environmental	Health	Ethical
Public	Affordability. Creation and distribution of added value. Contribution to economic development.	Information and communication. Food security.	Resource use. Pollution.	Nutrition. Food safety. Traceability.	Animal welfare. Responsibility. Labour relations. Fair trade.
Scientific	Contribution to economic development. Technological innovation. Governance.	Consumer behaviour. Territoriality.	Resource use. Biodiversity. Efficiency. Technological innovation. Food waste.	Nutrition. Food safety.	Fair trade. Animal welfare.
Market	Efficiency. Profitability/ competitiveness. Connection. Technological innovation. Resilience.	Information and communication. Territoriality. Connection.	Efficiency.	Food safety. Traceability.	Fair trade. Territoriality.
Policy	Creation and distribution of added value. Contribution to economic development. Efficiency. Resilience. Food waste.	Consumer behaviour. Labour relations.	Food waste. Pollution.	Nutrition. Food safety. Traceability	Food security Governance.

Figure 5. The reflection/reflexivity interaction of the application of ethical assessment tools to consider the use of AI or technology in food supply chains

		Ethical matrices (e.g. Mepham, 2000)	Multi-criteria performance matrix (Kirwan et al., 2017)
Voss & Kemp (2006) Integrating transdisciplinary knowledge production	Technical aspects of data	X or ✓	✓
	Ethical aspects of AI and machine learning	X or ✓	✓
	Ethical aspects of the practice being considered	✓	✓
	Ethical impacts of practice	✓	✓
Enabling iterative participatory goal formation	Role of reflexive governance.	X or ✓	X or ✓
Driving interactive strategy development		X or ✓	X or ✓
Adaptivity of strategies and institutions to address uncertainty or ambiguity		X	X
Ability to anticipate long term systemic effects of supply chain strategies		X	X

✓ Can be addressed X limited or unable to be addressed (Both indicators are mediated by skillset of those using the tools)

Table 1. Dimensions of a reflexive ethical governance architecture typology to consider the use of AI and machine learning (Adapted from Beranger, 2018; Ryan, 2022)

Technical aspects of data	**Ethical aspects of AI and machine learning**	**Ethical aspects of practice**	**Ethical impacts of practice**	**Reflexive governance**
Accessibility Consistency Integrity Organisation Protection Security Traceability	Automation Bias/non-bias Explicability Finality Interpretability Liability Protection Quality Reliability Self-determination Transparency	Accountability Advertising Automation Autonomy Confidentiality Culture Dehumanisation Deontology Dignity Diversity Equality Fairness Freedom Free will Governance Justice Management Plurality Privacy Regulation Safety Solidarity Trustworthiness	Accountability Communication Consistency Culture Disclosure Dehumanisation	Accountability Bias/ non-bias Benefits Confidentiality Culture Governance Integrity Liability Management Non-maleficence Organisation Power/ empowerment Privacy Regulation Responsibility Security Social good Sustainability Traceability Transparency Trust Trustworthiness