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Perspective

Considering the ethical implications of digital collaboration in the Food Sector

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

[1]Imagination Lancaster, LICA, Lancaster University, Lancaster, Lancashire LA1 4YW, UK
[2]The Lincoln Institute of Agri-Food Technology, University of Lincoln, Lincoln LN1 2LG, UK
[3]Future Food Beacon of Excellence and School of Biosciences, University of Nottingham, Sutton Bonington Campus, Nottingham LE12 5RD, UK
[4]School of Chemistry, Faculty of Engineering & Physical Sciences, University of Southampton, Southampton SO17 1BJ, UK
[5]School of Business and Management, Royal Holloway University of London, Egham TW20 0EX, UK
[6]Royal Agricultural University, Cirencester GL7 6JS, UK
*Correspondence: naomi.jacobs@lancaster.ac.uk
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THE BIGGER PICTURE This working group is aiming to create an ethical framework to elicit questions, facilitate discussions, and enable the exploration of the implications and consequences of digital collaboration in the food supply chain in line with the approach of responsible innovation. Ethics is a complex, diverse, and interdisciplinary area and cannot be formalized to provide a singular "right answer". Because technology has significant ethical implications, we must empower developers, companies, and other stakeholders to engage with this complexity. To do this, individuals and companies alike need to be provided with methods of understanding the issues and trade-offs that could arise from their technology and processes. This endeavor is not one that can be worked on alone; it requires an interdisciplinary team and the use of a range of methodologies to understand and frame the issues at stake. Furthermore, running this initiative as part of two networks has provided access to a wealth of further expertise to aid with evaluation and feedback on our research.

Concept: Basic principles of a new data science output observed and reported

SUMMARY

The Internet of Food Things Network+ (IoFT) and the Artificial Intelligence and Augmented Intelligence for Automated Investigation for Scientific Discovery Network+ (AI3SD) brought together an interdisciplinary multi-institution working group to create an ethical framework for digital collaboration in the food industry. This will enable the exploration of implications and consequences (both intentional and unintentional) of using cutting-edge technologies to support the implementation of data trusts and other forms of digital collaboration in the food sector. This article describes how we identified areas for ethical consideration with respect to digital collaboration and the use of Industry 4.0 technologies in the food sector and describes the different interdisciplinary methodologies being used to produce this framework. The research questions and objectives that are being addressed by the working group are laid out, with a report on our ongoing work. The article concludes with recommendations about working on projects in this area.

INTRODUCTION

With the increasing focus on food in today's modern world, from farm to table and everything in between, it is unsurprising that food production is the largest sector in the UK manufacturing industry.[1] The food sector is facing several overarching challenges, such as continuing to feed the ever-expanding population, reducing food waste, reducing environmental impacts of activities, and addressing different dietary and nutritional requirements.[2]

The so-called fourth industrial revolution[3] offers a wealth of opportunities in the food sector, especially through the implementation of novel technologies, such as distributed ledger technologies[4] and artificial intelligence (AI).[5] However, for these opportunities to be fully realized, there is a need to be able to securely collaborate, share, and access a wide variety of data sources across the entire food sector.[6,7] Meeting this need requires a trusted mechanism both to enable collaboration between the different parties throughout the supply chain and to support each party to make decisions about the credibility of

the separate data sources.[8] There is a plethora of data associated with and generated by each stage of the food supply chain. However, use of this data may currently be limited, with the result being that its innate value is not used productively or delivered equitably to actors across the food system.

To create such a data collaboration would require the integration of both cutting-edge technologies and surrounding social, institutional, and policy elements to ensure that the system works equally well and equitably for all parties involved. As with the advent of any new technology or system, this data collaboration brings a wealth of ethical implications to consider. For example, if AI is to be implemented, we need to address ethical challenges that are well known in this area, such as bias and accountability, to create systems that are responsible in their implementation and prioritize human wellbeing.[9,10] Such complex challenges can be considered as "wicked problems"[11] and require an interdisciplinary approach. In addition, by using holistic, speculative methods[12] that explore potentialities as well as current solutions it is possible to consider both novel solutions, and emergent risks that may not be evident purely by considering the current context.

This article first sets out the key areas in which the ethical implications need to be considered in the context of digital collaboration in the food sector with a particular focus on the use of AI in shared data management and utilization, and the importance of responsible innovation. We have chosen AI as a representative example of the type of fast-moving fourth industrial revolution data technologies that are bringing particular ethical challenges to this field.[3] Furthermore, AI can be seen as a converging sociotechnical system that consists of many interlinked ecosystems used by different actors interacting in complex ways (see Stahl[13]). Secondly, we report on ongoing work to define and contextualize emergent ethical questions. We present how the use of interdisciplinary research practices and methodologies, such as design fiction, can help to frame the transdisciplinary issues involved, assist in gathering expert perspectives on how to address such complex challenges, and support wider engagement of a range of stakeholders including industry and communities. This paper is based on work currently in progress as part of an interdisciplinary, multi-institution working group who are in the process of developing an ethical framework to enable the exploration of the implications and consequences (both intentional and unintentional) of using cutting-edge technologies to support the implementation of data trusts in the food sector. This is one of a number of working groups undertaking focused research on issues around the challenges of data trusts in food systems. This research is aligned to work funded by the Food Standards Agency and led by the University of Lincoln to create a data trust related to food safety (www.foodchain.ac.uk).

DIGITAL COLLABORATION IN THE FOOD SECTOR

Schwab[3] has described the fourth industrial revolution (also called Industry 4.0) as being characterized "by more ubiquitous and mobile internet, by smaller and more powerful sensors that have become cheaper, and by artificial intelligence and machine learning." The backbone of the integration of these technologies is the data that they utilize. These data are collected and generated in many ways, including by Internet of Things (IoT) sensors and other sources, creating large datasets on which machine learning algorithms and other AI tools can be used to generate valuable insight. To facilitate deriving economic, environmental, and social value from such large and diverse quantities of data, digital collaboration among supply chain actors and wider stakeholders is necessary.

The collaborative use of these new technologies has the potential to address some of the major challenges facing the food sector. These challenges include adopting processes to deliver efficiency, productivity, sustainability, traceability, transparency, and information disclosure, as well as assuring food safety, improving diets and health, minimizing food fraud, and reducing food loss and food waste.[5,14] For example, there have been several recent high-profile incidents where the unforeseen or unacknowledged presence of allergens within food products has caused illness or death, leading to calls for regulatory changes in mandatory labeling requirements[15] and improvements in the integrity of data used in supply chains.

The use of sensors and machine learning to predict and manage cross-contamination incidents in factories could reduce some of these risks.[16] However, the data that could contribute to solving these problems may be commercially and personally sensitive, are resource intensive to capture, and may lead to disproportionate advantages for some chain actors, for example, large agri-food conglomerates who own and exploit "big data" with negative ecological, economic, and health consequences.[17] For this reason, digital collaboration and the sharing of data require a degree of openness and trust. Trust and trustworthiness are already key factors in delivering integrated food supply chains and food networks.[4,18] How this trust is created and then evolves, is a complex process. These trust-based challenges become even more complex, and more pressing, when new technologies are introduced to either the food supply chain or the data-sharing process.

It has been proposed that new data governance and organization structures may be needed to facilitate trusted data sharing, to fully take advantage of the opportunities that the fourth industrial revolution can bring to society.[19] One such avenue for this is to establish data trusts. A report produced for the UK Department for Digital, Culture, Media & Sport and the Department for Business, Energy & Industrial Strategy in 2017 suggested that: "To facilitate the sharing of data between organizations holding data and organizations looking to use data to develop AI, Government and industry should deliver a program to develop data trusts—proven and trusted frameworks and agreements—to ensure exchanges are secure and mutually beneficial."[20] It has been suggested that such frameworks could function effectively where other mechanisms, such as commercial agreements, would be unsuitable.[21]

There are many definitions of data trusts, which cover a range of concepts from formal legal agreements to more conceptual framings.[22] The Open Data Institute (ODI) defines a data trust as: "a legal structure that provides independent stewardship of data."[23] The Internet of Food Things Network+ is exploring the concept of data trusts in the context of food production supply and has taken the ODI work as a foundation. Network members, including authors of this paper, have contributed to developing a working definition of a data trust as part of the network's

research activities, which we are using for the purposes of this research. This definition is as follows: ''The concept of a data trust is a mechanism to collate data from multiple sources, either physically, or virtually, to be managed or orchestrated in some way on behalf of all of the parties through independent, fiduciary stewardship of data.''

This digital collaboration framework could include a range of fourth industrial revolution technologies, such as distributed ledger technologies (e.g., blockchain) and AI technologies.

ETHICAL CHALLENGES OF DATA SHARING AND AI

There are many well-known examples where autonomous systems that use AI and machine learning result in unintended and harmful consequences. Such systems are popular because they are efficient, flexible, and are quick to react to complex systems; however, this in turn can lead to unanticipated, undesirable outcomes. Examples include unintended bias,[24] violations of privacy,[25] and fatal accidents.[26] Consequences can arise from the behavior of the systems or as a result of the ways in which they are conceived, designed, deployed, or used. It is important that all parts of the application life cycle are considered to ensure responsible and ethical use in the design and deployment of these technologies. Despite significant discussion on these ethical issues across many fields of academic study, and a plethora of ethical guidelines being published by businesses, governments, professional organizations, and others, there are still few binding regulations and mutually agreed normative standards for ethical use of AI.[27] However, this work is ongoing, for example, in the development of a new set of standards for ethical autonomous and AI systems.[10]

Many of these ethical challenges relate to issues of trust and transparency, which, as previously highlighted in this paper, are also key considerations with regard to the operation of the food supply chain more generally. In the case of systems that use AI, it is important that the function and decision-making capabilities of the systems are transparent in order that accountability and auditability can be ensured. We must understand how the ethical concerns are framed and operationalized to identify where the use of such systems may introduce new risks and challenges. Examples include areas such as bias and privacy, as well as wider ethical concerns, such as sustainability, and the impact of automation on labor and wellbeing. Rather than evaluating the technical challenges of adopting and integrating a data collaboration framework (as other working groups are doing[22]), our working group focusses specifically on identifying and classifying conceptions and understandings of the ethical issues, and on the long-term implications of creating a framework that relies on the characteristics and efficacy of the technologies employed. In this way, it is intended that these considerations can be incorporated into the technical development process, with a goal of facilitating progress toward ethics by design whereby ethical considerations are raised during the design process and they become design requirements integral to the technology under development, designed from the start rather than applied retrospectively.

These ethical implications are emergent from the utilization of these technologies, whether they are used by single or multiple actors, in isolation or in consortia. It is critical that ethical implications must be addressed if such technology is to be implemented in a way that is responsible and socially beneficial.

RESPONSIBLE (RESEARCH AND) INNOVATION

Examining the ethical implications of emerging technology situates this current work in a wider discourse that has become known as responsible innovation (RI) with its policy counterpart being known as responsible research and innovation (R(R)I) as part of the EU's horizon 2020 framework program. This has developed out of predecessors such as Appropriate Technology, Technology Assessment and Science and Technology Studies[28] and the Ethical Legal and Social Aspects of Technology among others.[29,30] There are many facets to R(R)I with its definition and scope subject to multiple perspectives. Having said this, it has been summarized as: ''a transparent, interactive process by which societal actors and innovators become mutually responsive to each other with a view on the (ethical) acceptability, sustainability, and societal desirability of the innovation process and its marketable products (in order to allow a proper embedding of scientific and technological advances in our society).[31]

Stilgoe et al.[32] expand this to a more general definitions meaning: "taking care of the future through collective stewardship of science and innovation in the present.''

Given these definitions, there has been much work on integrating these elements into the operation and governance of RI activities. For example, R(R)I considerations have been embedded in the development of specific technologies, such as smart information systems (SHERPA),[33] human genomics, human enhancement and human machine interaction (SIENNA),[34] or approaches to ethical assessment of RI (SATORI)[35] alongside other approaches technologies, such as nanotechnology[36] and geoengineering.[32]

These emerging technologies are all subject to uncertainty in their development and impact and what is known as the Collingridge Dilemma,[37] which states that ''attempting to control a technology is difficult … because during its early stages when it can be controlled, not enough can be known about its harmful social consequences to warrant controlling its development; but by the time these consequences are apparent, control has become costly and slow.'' This requires steps to be taken to try and anticipate the impact of emerging technology and make changes to its development and implementation before they become more difficult. One potential approach is what is known as the precautionary principle where steps are taken to mitigate potential negative impacts of a technology even when these impacts are subject to considerable uncertainty. This has been seen to be a barrier to technological progress but instead it is intended to act as a safeguard against potential future negative impacts so that they can be addressed before the impact has become embedded and difficult to change. A wide variety of approaches have been developed to address these difficulties in engaging with the ethics of emerging technology. Reijers et al.[38] provide a review which classifies such approaches into ex ante (for example, anticipatory technology ethics and

scenario approaches), intra (for example, value sensitive design and ethical impact assessment), and ex post (for example, checklist approaches or the ethical matrix) methods depending on whether they are undertaken before, during, or after the technology development process indicating the complexity of the issues at stake and the variety of approaches proposed for addressing them.

The potential impacts and social context of emerging technologies is varied and hard to predict, especially when considered in logically malleable computational technologies such as AI. R(R)I therefore requires scientists and stakeholders in research and innovation themselves to develop skills to reflect on their own practice and engage with stakeholders in an upstream manner[39] to consider and work toward a societally desirable innovation, in all aspects of their work. To this end R(R)I has been generalized into several frameworks, approaches, tools, and forms of measurement to enable and ensure responsible innovation. For example, Stilgoe et al. formulate R(R)I as a four-stage process to enable the Anticipation, Reflexivity, Inclusion, and Responsiveness of Research and Innovation to the concerns of society.[32] This has been adapted and adopted for example by the UK's Engineering and Physical Sciences Research Council and their AREA framework, which asks researchers to Anticipate, Reflect, Engage, and Act in relation to the societal aspects of their research,[40] which has been aided by the specification of an accompanying "4P" process asking them to consider the Purpose, Process, People, and Product of their research across the AREA framework.[41] In practice, this generalized structure has been considered too vague and non-specific for individual research projects to adopt and "do" R(R)I for their project. To mitigate this, there have been considerable efforts to provide accessible tools, across subjects and domains to make R(R)I elements accessible, engaging, and implementable, as illustrated by the breadth of the information, case studies, and tools made available through the RRI tools website.[42]

The project discussed in this paper brings together different disciplines and groups at the intersection of food and technology research and innovation research communities. The project is focused on aiding the discursive engagement with different stakeholder communities, both through exploring and producing a shared glossary and in using design fiction to creatively anticipate the data trust model and its application in the food sector through the reflective co-creation of speculative design artifacts. These tools and outcomes will act as an exemplar of how such methods can be used to engage with wider stakeholders. Further engaged reflection using an ethics by design tool will result in the creation of an ethical framework to inform future reflections, engagement, and actions in this space from the research, governance, business, and civil society organizations and beyond.

Not only will the work represent a grounded reflexive engagement with the ethics of data sharing in the food system, but this will act as an example of a novel, engaged reflexive, co-creation methodology to potentially act as a model for further engagement. Furthermore, this work addresses some of the recommendations and shortcomings identified by Reijers et al.[38] with emerging technologies to enable them to be developed toward the goals of R(R)I.

CHALLENGES OF ADDRESSING ETHICS IN THE USE OF AI IN DIGITAL COLLABORATION IN THE FOOD SECTOR

To begin to address some of these challenges, it is necessary to bring together interdisciplinary teams with a range of expertise and knowledge. It is critical that we consult those with expertise in digital technology; for example, distributed ledger technologies and machine learning. However, we also need contributions from those with in-depth knowledge of the food sector and the current ways in which supply and distribution chains function, as well as legal scholars who can construct new regulatory and governmental frameworks for data sharing. It will also be beneficial to have input from philosophers who can unpick some of the complex ethical challenges that arise from these new technologies, which raise new conceptual and contextual questions such as: How do we frame the nature of responsibility when AI autonomous agents are part of functional and decision-making systems and act on behalf of supply chain actors and ultimately consumers? It is also important to consider expertise from outside the academy, and engage (as responsible innovation advocates) with a wider range of stakeholders including industry, policymakers, and the public, who have vested interest in the development of these systems. This can be particularly challenging to accomplish.

Such collaborations across disciplines and sectors are necessary and fundamental to tackling these issues. However, working collaboratively with people who have different disciplinary backgrounds can result in its own co-creational challenges. A significant barrier to the development and enacting of effective interdisciplinary collaboration is the lack of a shared common language.[43] This may manifest in subtle ways; for example, the term transparency, utilized already in this paper, is used commonly across many different discussions of this topic but can have very different meanings to those using it (in addition to meanings from everyday language), depending on the discipline from which they come. Transparency might have a range of meanings relating to the ability to have full access to the algorithms and associated training data when considering AI systems.[44] It might also mean that opacity and information asymmetry is reduced and, as a result, actors have accurate data associated with the traceability and provenance of food items. In the case of certain disciplines, such as computer interaction design, it might even mean something entirely contradictory: the ability of devices and sensor-based systems to operate in such a way that they blend into the background and are not consciously considered by those using them.[45] For this reason, we suggest that the first stage in the construction of an ethical framework in this complex area must be a co-created set of definitions of terms to develop a common understanding for discussing ethical issues that may arise and their consequences.

A MULTIDISCIPLINARY APPROACH

The Ethics of AI in Food Data Trusts Working Group was established to investigate and frame the ethical issues that arise from the creation and use of a data trust, and how the potential negative or unintended consequences of using Industry 4.0 technologies to facilitate a data trust model between many collaborative

Table 1. Research questions and aims

Research questions	Research aims
RQ1: How can we translate well-established ethical issues for cutting-edge technologies to the particular context of the food industry, to support wider discussion about ethics in digital collaboration systems?	RA1: Identify ethical issues (both obvious/unobvious and intentional/unintentional) of using cutting-edge technologies to create and implement a large-scale data trust model for collaboration and data sharing.
RQ2: What tools are needed to support those who are sharing data in ensuring that they provide individuals with the necessary information and tools to make ethical decisions about, for example, allergens data, if they want to? This should be considered on both a small individual scale and a large corporation scale in a food network.	RA2: Identify potential mitigations/solutions to these ethical issues of sharing data between supply chain actors.
RQ3: Can we develop tools that enable evaluation of whether a data trust model benefits and is accessible to all related parties irrespective of size, resources, or access to technology?	RA3: Identify a set of strategies to provide individuals at each stage of the food supply chain with the necessary tools and information to identify and make ethical decisions about (allergens-related) data, if they want to? RA4: Address diversity and inclusivity in all aspects of our work.

parties can be mitigated. Table 1 describes our research objectives and aims. Through initial scoping work, we identified sharing data about allergens as a conceptual scenario on which we could base our research. This allergens case study, which included the use of AI for classification and prediction, therefore became the focus of our studies and examples; both to identify why an ethical framework is necessary and how one could be implemented within a specific context.

Our working group comprises researchers from different disciplines who have extensive experience working in interdisciplinary research projects, as well as industry experience within the food sector. Our skillsets include technical expertise in AI, semantic web, and IoT Technologies, ethics and law, in addition to experience in food safety, food integrity, and food sustainability risk assessment and risk mitigation. The team also includes design researchers who bring new methodological approaches to bear on these challenges, including the use of speculative design and design fiction, which can be used for wider participatory approaches and stakeholder engagement.[46]

Speculative design is a design methodology that aims to provoke discussion by using speculation to consider potential, plausible, or possible future outcomes of current directions in societal or technological development. These speculative outcomes are not intended to be predictive or suggest how things should be, but instead provide opportunities for discussion. In their influential work "Speculative Everything," Dunne and Raby[12] suggest that, "Props used in design speculations are functional and skilfully designed; they facilitate imagining and help us entertain ideas about everyday life that might not be obvious. They help us think about alternative possibilities—they challenge the ideals, values, and beliefs of our society embodied in material culture."

The development of tangible objects that represent and embody technological design speculations is known as design fiction, a method popularized by Julian Bleeker.[47] Design fiction is the process of creating prototypical objects that are physical manifestations of a fictional shift in the world, which may reflect alternate pasts or presents or speculated futures. These design fictions can be used to engage with multiple stakeholders and assist in considering complex issues that might result from the deployment of technology. For example, Jacobs et al.[46] created objects representing a fictional deployment of IoT-enabled dustbins and used these objects in participatory work with the local community to consider questions of data access, privacy, and transparency. These objects included informational leaflets and resident access cards distributed by the local council as well as press coverage of public pushback on the privacy implications of the devices.

Because data collaboration frameworks in the food sector are part of complex existing systems, and there are many potential opportunities and solutions to address these challenges, they are a good example of so-called "wicked problems."[11] Design fiction is a useful method by which to address such wicked problems, because potential solutions can be evaluated without designing and building expensive fully working prototype systems, cutting through the Collingridge Dilemma described above. If a system is built in its entirety, it may have to be fully redesigned when issues are found. This could prove costly and result in damaging outcomes if such issues are only revealed when the systems are deployed in the real world, and stakeholders interact with them in real-world contexts.

In this project we are therefore combining the design fiction work with another key method, that of ethical reflection, engagement, and evaluation using a card-based tool, specifically Moral-IT cards. The Moral-IT cards have been developed as a tool to prompt reflection on the legal, ethical, technical, and social implications of new information technologies.[48] The reflective use of the Moral-IT cards has many flexible applications, one of which is to help technology developers work toward "ethics by design," as noted above where ethical considerations are raised during the design process and ethical requirements become integral to the technology under development.

The Moral-IT cards ask open questions across a range of principles, grouped into four loose overlapping categories or suits of Ethics, Security, Privacy, and Law (as well as Narrative prompts) (see Figure 1). These questions are all posed in relation to "your technology," which is the technology under consideration in the

Figure 1. The Moral-IT card categories or "suits"

exercise. Previous work has shown that the Moral-IT cards work flexibly across a range of IT-based technologies to enable developers to ethically consider their work. The flexibility of their use allows for the expression of a range of perspectives, anchored through the shared resources of the cards to facilitate the ethical assessment of technology.[48] Through the use of combining design fiction and these cards, we can explore speculative ethical challenges.

To contribute to the development of our ethical framework our approach, therefore, has three methodological strands that contribute to a novel responsible innovation approach.

Create common glossary

The glossary will be constructed through a multidisciplinary literature review and iterative collaborative discussion to reflect the interdisciplinary scope of this activity. It will allow us to map out the key understandings of the different disciplinary definitions of concepts related to ethics within the food industry and supply chain. Through this we can develop a shared understanding and enable discussions across different disciplines and sectors.

Create a speculative design for a data trust model

This research method will synthesize the expertise of the working group and identify challenges that emerge from the glossary exercise to create design fiction objects; tangible and explorable items that represent a fictional future data trust based on plausible extrapolations of proposed models. These design fictions will be used within the project for evaluation and to demonstrate a methodology that can be used in subsequent work to enable a wide range of stakeholders to engage with the operation of a data trust and explore the ethical issues and potential barriers to its operation. The design fiction objects will revolve around the use-case of monitoring and tracking of food allergens in the food supply chain in a system that includes AI prediction and classification.

Evaluation of speculative design project

The design fictions will be ethically "assessed" using the Moral-IT cards, which were developed to support and encourage the "ethics by design" of technology. This research method will help to identify and prioritize emergent ethical issues and concerns in the design and use of a data trust system for the food system, with particular focus on the management of food allergens.

PRELIMINARY FINDINGS

We have found that the process of bringing together an interdisciplinary team has itself yielded promising insights into this topic. Ideas that were initially developed in a 2-day research retreat have been developed through collaborative working and a series of workshops. (These were held online due to COVID-19 restrictions, which required the development of some novel tools for remote collaboration.) In the first of these workshops, the allergen model that was proposed at the retreat event was developed further via a process of speculative worldbuilding. This process (following Coulton et al.[49]) aims to construct not a single speculative object or a narrative scenario, but rather a cohesive "world" which can be probed and explored, and which can be further explicated through representative design fiction objects which instantiate and concretize its features. In this case, our model included identifying different actors who would interact with the data trust as well as features of the data storage and functions of AI processes that would act within it, such as prediction systems to provide producers with information on likely periods of increased demand in the event of a contamination incident (see Figure 2).

Based on this work, four design fiction objects were developed through a grounded, iterative process to represent plausible elements of the future implementation of a food data trust and associated sociotechnical systems. These include a documentary film, minutes from the meeting of the governance board managing the data trust, the design and use by consumers of a smart phone app, and the use of smart packaging that uses shared data (see Figure 3). We held a participatory workshop whereby external academic participants with a range of domain expertise (including computer science, law, and food) assessed these objects using the Moral-IT cards.

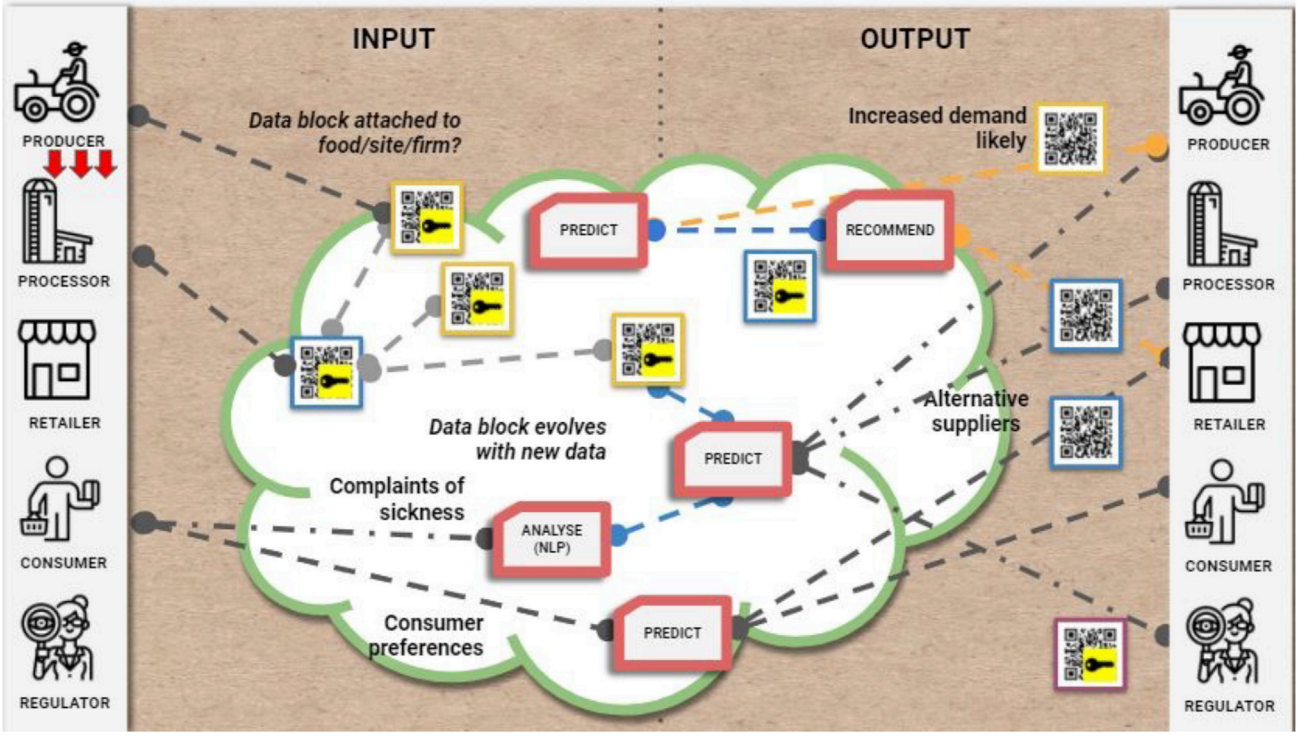

Figure 2. Speculative world building preliminary model

During this process, the participants were asked to identify: potential ethical benefits and harms of the technology, ways of maximizing the benefits and minimizing the harms, as well as the pragmatic challenges of implementation of these maximization and minimization strategies. The workshop discussions were prompted and anchored by the questions and cards in relation to the design fiction artifacts. By analyzing the data from this activity, we aim to reveal emergent themes important to the overall data trust concept. For example, how people view the technology according to how they are situated in relation to it (e.g., whether allergen tracking is of concern to them), particular concerns of the use of AI (e.g., whether issues of bias and fairness disproportionally affect some stakeholders), and how the ethical challenges of a system may relate to the wider sociotechnical context of which it is part. Using such a flexible and pragmatic tool to ethically assess the design artifacts provides insights generated in response to "real" scenarios to enable the development of an ethical framework based on the reality of an as yet undeveloped system. This will give the ethical framework a pragmatic grounding that would be lacking from a more abstract approach to the potential implementation of a data trust within the food system and will reveal how this methodological approach compares with those developed for practising ethics and responsible innovation in relation to technology as noted above.[38]

FUTURE WORK: CREATING AN ETHICAL FRAMEWORK

Having conducted the research through these different activities, our working group plans to collate the extensive findings to create an ethical framework. This framework is conceived as a mechanism for parties at all stages of the digital food chain to identify ethical questions, risks, and trade-offs that need to be considered for their systems to contribute to responsible innovation.

Through undertaking this multidisciplinary research, it has become apparent that there is significant value in a combined methodological approach of this nature. Often in work pertaining to such complex systems and theoretical questions, the starting point may be a set of generalized principles, such as transparency and trust. By contrast, our approach started from a situated, plausible, and tangible (although fictional) instantiation (that is, example) of a data trust in operation, which provided valuable grounded insight. The fact that this data trust is a speculative fiction means that this interrogation could take place without having to wait for technical or practical implementation, which could take many years, potentially mitigating some of the impact of the Collingridge Dilemma as discussed above.

An ethical assessment developed from first principles would also have been impeded by the need to coalesce complex and varied understandings of ethical terms across perspectives, as demonstrated through the creation of a shared glossary and vocabulary which took considerable work. Starting with the technology rather than the ethics helps to mitigate this issue and has allowed for valuable insight into the ethical considerations of a data trust to emerge, an approach that may be valuable and applicable more widely in the context of responsible innovation.

With respect to the diverse ethical questions and issues surrounding digital collaboration and the use of AI in the food

Figure 3. Design fiction object: smart packaging

industry we have found that, unsurprisingly, there are no simple "right or wrong" answers. There are complex issues at stake, and trade-offs to be considered. For example, our workshops included discussion of the multiple competing environmental impacts that could require compromise. Creating systems to evaluate the environmental impact of different food solutions with a view to reduce environmental damage must be balanced against the environmental impact that harnessing the required additional computing power would have. Before anyone can start to make ethical decisions, a pragmatically emergent and grounded framework needs to be in place to highlight all of the different elements that need to be considered such that users of the framework can be empowered to make informed decisions.

RECOMMENDATIONS AND CONCLUSIONS

Working on this project has made it very clear that it is absolutely vital to have an interdisciplinary team. Ethics is a complex interdisciplinary issue and as such needs to be understood across a range of different domains. Preliminary discussions demonstrated that there are disparate meanings and understandings of the core ethical terms (such as transparency and accessibility) across different domains, and as such it is imperative to work to develop a shared understanding of the language used. While our working group did include those with practical industry experience, the majority of the group are academics. The pilot project was limited in scope and reach due to resource constraints, and we therefore suggest that further work should take a similar methodological approach but extend this to include a much wider range of stakeholders and expertise, including from outside academia in line with the focus on engagement at the heart of responsible innovation.

A key aspect that keeps arising is the need to plan and consider ethical issues of digital collaboration *before* embarking on their creation and usage. Using a range of methodologies, such as design fiction and the Moral-IT cards, enables researchers, managers, and designers, in both an industry and an academic context, to explore potential ethical issues from the start rather than after system development. Most importantly, an iterative approach is key, as ethical considerations need to develop alongside changing digital collaboration developments. Such considerations speak to responsible innovation and its requirement to anticipate and reflect on potential impacts of technology in advance. The creative combination of "design fiction" and "ethics by design" methods developed here to potentially act as a valuable way of engaging with the ethical acceptability of emerging technology, mitigate elements of the Collingridge Dilemma and help them to be aligned to be more societally desirable overall.

EXPERIMENTAL PROCEDURES

Resource availability

Lead contact

Further information and requests for resources should be directed to and will be fulfilled by the lead contact, Naomi Jacobs (naomi.jacobs@lancaster.ac.uk).

Materials availability

This study did not generate new unique materials, beyond the use-specific design fiction objects, which can be viewed via contacting the lead contact.

Data and code availability

The qualitative data reported in this study cannot be deposited in a public repository because of ethical considerations and identifiable personal information.

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AUTHOR CONTRIBUTIONS

N.J. initiated the paper and drafted the initial manuscript. This was based on the working group proposal documents that were collaboratively developed by all authors. N.J. and J.S. led the design fiction process, and P.J.C. led the use of the Moral-IT cards. All authors took part in the workshops and read and provided input into the manuscript. S.K. and S.M. helped revise the final manuscript. The working group was led by S.K. with support from S.M. and S.B.

DECLARATION OF INTERESTS

The authors declare no competing interests.

REFERENCES

1. (2021). FDF public site: home. https://www.fdf.org.uk/.
2. Kowalska, A., and Manning, L. (2020). Using the rapid alert system for food and feed: potential benefits and problems on data interpretation. Crit. Rev. Food Sci. Nutr. *0*, 1–14.
3. Schwab, K. (2017). The Fourth Industrial Revolution (Crown), p. 194.
4. Pearson, S., May, D., Leontidis, G., Swainson, M., Brewer, S., Bidaut, L., et al. (2019). Are distributed ledger technologies the panacea for food traceability? Glob. Food Secur. *20*, 145–149.
5. Brewer, S., Pearson, S., Pauli, M., Leveson-Gower, H., Frey, J., Maull, R., et al. (2019). Digital Collaboration in the Food and Drink Production Supply Chain (Zenodo). https://zenodo.org/record/3368237.
6. Wolfert, S., Ge, L., Verdouw, C., and Bogaardt, M.-J. (2017). Big data in smart farming—a review. Agric. Syst. *153*, 69–80.
7. Marvin, H., Janssen, E., Bouzembrak, Y., Hendriksen, P., and Staats, M. (2017). Big data in food safety: an overview. Crit. Rev. Food Sci. Nutr. *57*, 2286–2295.
8. Jakku, E., Taylor, B., Fleming, A., Mason, C., Fielke, S., Sounness, C., et al. (2019). "If they don't tell us what they do with it, why would we trust them?" Trust, transparency and benefit-sharing in Smart Farming. NJAS - Wageningen J. Life Sci. *90–91*, 100285.
9. Dignum, V. (2019). Responsible Artificial Intelligence: How to Develop and Use AI in a Responsible Way (Springer Nature), p. 133.
10. Chatila, R., and Havens, J.C. (2019). The IEEE global initiative on ethics of autonomous and intelligent systems. In Robotics and Well-Being, M.I. Aldinhas Ferreira, J. Silva Sequeira, G. Singh Virk, M.O. Tokhi, and E. Kadar E, eds. (Springer International Publishing), pp. 11–16. Intelligent Systems, Control and Automation: Science and Engineering. https://doi.org/10.1007/978-3-030-12524-0_2.
11. Durant, R., and Legge, J. (2006). "Wicked problems," public policy, and administrative theory: lessons from the GM food regulatory arena. Adm. Soc. *38*, 309–334.
12. Dunne, A., and Raby, F. (2013). Speculative Everything: Design, Fiction, and Social Dreaming (MIT Press), p. 235.
13. Stahl, B.C. (2021). Artificial intelligence for a better future—an ecosystem perspective on the ethics of AI and emerging digital technologies. https://www.springer.com/gp/book/9783030699772.
14. Manning, L., and Soon, J.M. (2014). Developing systems to control food adulteration. Food Policy *49*, 23–32.
15. Gregory, D. (2018). From the chief executive and IFST news. Food Sci. Technol. *32*, 8–12.
16. Porcheron, M., Watson, N., Fischer, J.E., and Reeves, S. (2020). The future of factory cleaning: responsible cleaning data collection and use framework. http://doi.org/10.17639/nott.7054.
17. Bronson, K., and Knezevic, I. (2016). Big Data in food and agriculture. Big Data Soc. *3*. https://doi.org/10.1177/2053951716648174.
18. Murphy, B., Benson, T., Lavelle, F., Elliott, C., and Dean, M. (2021). Assessing differences in levels of food trust between European countries—ScienceDirect. Food Control *120*, 107561.
19. Luthra, S., and Mangla, S.K. (2018). Evaluating challenges to Industry 4.0 initiatives for supply chain sustainability in emerging economies. Process. Saf. Environ. Prot. *117*, 168–179.
20. Hall, W., and Pesenti, J. (2017). Growing the Artificial Intelligence Industry in the UK (Department for Digital, Culture, Media & Sport and Department for Business, Energy & Industrial Strategy. Part of the Industrial Strategy UK and the Commonwealth.).
21. Stalla-Bourdillon, S., Wintour, A., and Carmichael, L. (2019). Building Trust through Data Foundations. A Call for a Data Governance Model to Support Trustworthy Data Sharing (Web Science Institute), p. 31.
22. Durrant, A., Markovic, M., Matthews, D., May, D., Leontidis, G., and Enright, J. (2021). How might technology rise to the challenge of data sharing in agri-food? Glob. Food Secur *28*, 100493.
23. Hardinges, J., and Wells, P. (2018). Defining a 'Data Trust' (Open Data Institute Blog). https://theodi.org/article/defining-a-data-trust/.
24. Caliskan, A., Bryson, J.J., and Narayanan, A. (2017). Semantics derived automatically from language corpora contain human-like biases. Science *356*, 183–186.
25. Tockar, A. (2021). Riding with the stars: passenger privacy in the NYC Taxicab Dataset—Neustar research blog. http://content.research.neustar.biz/blog/differential-privacy/QueriesWidget.html.
26. N. T. S. Board. Collision between a car operating with automated vehicle control systems and a tractor-semitrailer truck near Williston, Florida, May 7, 2019. 2017. Report no.: Accident Report NTSB/HAR-17/02, PB2017-102600.
27. Haas, L., Gießler, S., and Thiel, V. (2020). In the Realm of Paper Tigers—Exploring the Failings of AI Ethics Guidelines (AlgorithmWatch). https://algorithmwatch.org/en/ai-ethics-guidelines-inventory-upgrade-2020/.
28. Shanley, D. (2021). Imagining the future through revisiting the past: the value of history in thinking about R(R)I's possible future(s). J. Responsible Innov. *0*, 1–20.
29. Zwart, H., Landeweerd, L., and van Rooij, A. (2014). Adapt or perish? Assessing the recent shift in the European research funding arena from 'ELSA' to 'RRI'. Life Sci. Soc. Policy *10*, 11.
30. Owen, R., Macnaghten, P., and Stilgoe, J. (2012). Responsible research and innovation: from science in society to science for society, with society. Sci. Public Policy *39*, 751–760.
31. von Schomberg, René, Directorate-General for Research and Innovation (European Commission) (2011). Towards Responsible Research and Innovation in the Information and Communication Technologies and Security Technologies Fields (Publications Office of the European Union). http://op.europa.eu/en/publication-detail/-/publication/60153e8a-0fe9-4911-a7f4-1b530967ef10.
32. Stilgoe, J., Owen, R., and Macnaghten, P. (2013). Developing a framework for responsible innovation. Res. Policy *42*, 1568–1580.
33. (2021). Project Sherpa—shaping the ethical dimensions of smart information systems a European perspective. https://www.project-sherpa.eu/.
34. Fernow, J. (2021). SIENNA (Uppsala University). https://www.sienna-project.eu/.
35. (2021). Satori. https://satoriproject.eu/.
36. Felt, U., Schumann, S., Schwarz, C.G., and Strassnig, M. (2014). Technology of imagination: a card-based public engagement method for debating emerging technologies. Qual. Res. *14*, 233–251.
37. Genus, A., and Stirling, A. (2018). Collingridge and the dilemma of control: towards responsible and accountable innovation. Res. Policy *47*, 61–69.
38. Reijers, W., Wright, D., Brey, P., Weber, K., Rodrigues, R., O'Sullivan, D., Gordijn, B., et al. (2018). Methods for practising ethics in research and innovation: a literature review, critical analysis and recommendations. Sci. Eng. Ethics *24*, 1437–1481.
39. Wynne, B. (2002). Risk and environment as legitimatory discourses of technology: reflexivity inside out? Curr. Sociol. *50*, 459–477.
40. (2021). Framework for responsible innovation—EPSRC website. https://epsrc.ukri.org/research/framework/.
41. AREA 4P Framework | Orbit RRI [Internet]. Orbit. [cited 2021 May 28]. Available from: https://www.orbit-rri.org/about/area-4p-framework/
42. (2021). RRI tools. https://rri-tools.eu/.

43. Jacobs, N., and Amos, M. (2011). NanoInfoBio: a case-study in interdisciplinary research. In Applied research and professional education proceedings of the first CARPE networking conference, J. Kettunen, . Hyrkkänen U, and A. Lehto, eds. (University of Turku), pp. 289–309.

44. Larsson, S., and Heintz, F. (2020). Transparency in artificial intelligence. Internet Policy Rev. *9*. https://policyreview.info/concepts/transparency-artificial-intelligence.

45. Bardram, J.E., and Bertelsen, O.W. (1995). Supporting the development of transparent interaction. In Human-Computer Interaction, B. Blumenthal, J. Gornostaev, and C. Unger, eds. (Springer), pp. 79–90, (Lecture Notes in Computer Science).

46. Jacobs, N., Markovic, M., Cottrill, C., Edwards, P., Corsar, D., and Salt, K. (2020). Made-up rubbish: design fiction as a tool for participatory internet of things research. Des. J. *23*, 419–440.

47. Bleeker, J. (2009). A Short Essay on Design, Science, Fact and Fiction (Near Future Laboratory). https://shop.nearfuturelaboratory.com/products/design-fiction-a-short-essay-on-design-science-fact-and-fiction.

48. Urquhart, L., and Craigon, P.J. (2021). The Moral-IT deck: a tool for ethics by design. J. Responsible Innov. *8* (1), 94–126. https://doi.org/10.1080/23299460.2021.1880112.

49. Coulton, P., Lindley, J., Sturdee, M., and Stead, M. (2017). Design fiction as world building, 163–179 https://figshare.com/articles/journal_contribution/Design_Fiction_as_World_Building/4746964.

About the Authors

Naomi Jacobs is Lecturer in Design Policy and Futures Thinking at Imagination Lancaster, the design-led interdisciplinary research group at Lancaster University. Her work crosses various disciplines including design, computer science, and social science. Naomi's previous work has focused primarily on interaction; between individuals, communities, disciplines, or sectors, and between people and technology and the media they consume. Naomi is particularly interested in the intersection between the digital and the physical and how this impacts society on many axes. She has been part of a number of research projects looking at how technologies, such as IoT and AI, are being implemented and governed and is interested in how design can be used to shape policy for new technologies. In particular, her current work focuses on issues such as trust, transparency, privacy, and bias using speculative design methods to explore implications of technology currently in development or proposed for the future.

Steve Brewer is Network Coordinator of the UKRI- Engineering and Physical Sciences Research Council (EPSRC)-funded Internet of Food Things Network Plus, an interdisciplinary initiative which is working to reduce food waste, increase nutritional value and productivity, and reduce environmental impact across the supply chain. The IoFT is led from The Lincoln Institute for Agri-Food Technology at the University of Lincoln. Steve is also leading Lincoln's involvement in a number of Innovate UK projects including Digital Sandwich. Steve is a part-time doctoral candidate at the University of Southampton investigating the role of a previous Network Plus, IT as a Utility as a Living Laboratory. Steve has previously led and supported various interdisciplinary research projects at a UK and EU level focused on the use and reuse of data. Roles have also included Chief Community Officer for the European Grid Infrastructure, Network Coordinator of IT as a Utility, and dissemination lead for the EDISON Data Science Framework.

Peter J. Craigon is a Research Fellow in Ethics, Legislation and Engagement in Food and Agricultural Innovation within the Future Food Beacon of Excellence at the University of Nottingham. He is working on developing tools to encourage ethical engagement and regulatory responsiveness for researchers working in food and agricultural innovation and beyond. He previously worked at the Horizon Digital Economy Research Institute at the University of Nottingham developing tools to enable ethical design of IT-based technologies and also at the University of Nottingham School of Veterinary Medicine and Science researching dog behavior, particularly guide dogs. Alongside this he completed a multidisciplinary PhD at the Horizon Center for Doctoral Training also at the University of Nottingham exploring how social maps create knowledge about place.

Anabel Gutierrez is a Senior Lecturer in Digital Marketing at Royal Holloway University of London with over 25 years of academic experience, which she has balanced with industrial practice gained from consultancy work in IT projects for private and public sectors. Her research focuses on innovation and adoption of emerging technologies for the digital economy with a particular interest in data privacy concerns, the use of data to understand consumer behavior, and how to improve data-driven decision making. Anabel has collaborated in various initiatives with industry to bring together research-teaching-practice. She has published several articles in international peer-reviewed journals, conferences, edited books, as well as acting as a reviewer. Currently, she is a member of the SAS UK & Ireland Academic Advisory Board, Co-Chair of the Digital Marketing and Analytics SIG at the Academy of Marketing and member of the International Editorial Review Board of the International Journal of Information Management.

Jeremy Frey is a Professor of Physical Chemistry and the head of the Computational Systems Chemistry Group at the University of Southampton. Before working at Southampton, he obtained his DPhil on experimental and theoretical aspects of van der Waals complexes in the Physical Chemistry Labs, Oxford University, under the supervision of Professor Brian Howard, followed by a NATO/EPSRC fellowship at the Lawrence Berkeley Laboratory and University of California, with Professor Y.T. Lee. Jeremy's experimental research probes molecular organization in environments from single molecules in molecular beams to liquid interfaces using laser spectroscopy from the IR to soft X-rays. He investigates how e-Science infrastructure supports scientific research with an emphasis on the way digital infrastructure can enhance the intelligent creation, dissemination, and analysis of scientific data.

Samantha Kanza is an Enterprise Fellow at the University of Southampton. She completed her MEng in Computer Science at the University of Southampton and then worked for BAE Systems Applied Intelligence for a year before returning to do an iPhD in Web Science (in Computer Science and Chemistry), which focused on Semantic Tagging of Scientific Documents and Electronic Lab Notebooks. She was awarded her PhD in April 2018. Samantha works in the interdisciplinary research area of applying computer science techniques to the scientific domain, specifically through the use of semantic web technologies and artificial intelligence. Her research includes looking at electronic lab notebooks and smart laboratories, to improve the digitization and knowledge management of the scientific record using semantic web technologies, and using IoT devices in the laboratory. She has also worked on a number of interdisciplinary semantic web projects in different domains, including agriculture, chemistry, and the social sciences.

Louise Manning has worked for over 35 years in the agri-food supply chain in a range of roles. Her expertise is in the area of food security and food integrity including food safety, food quality, food crime, policy and governance, social and corporate responsibility, resilience, and risk assessment and mitigation strategies. Louise has carried out projects for government bodies and companies throughout Europe and Africa. This work includes strategic risk analysis and mitigation for both corporate organizations and public bodies. She has been published in peer-reviewed journals, authored book chapters, and written and edited books in the subject area. Louise's research work also involves undertaking desktop reviews; qualitative and quantitative fieldwork, including focus groups, workshops, and in-depth interviews, questionnaire design and analysis, strategic framework, communication systems, and model design and developing tools to drive risk communication and engagement of stakeholders at all levels of the supply chain.

Samuel Munday is a Research Assistant at the University of Southampton. He is currently part of the ICURe program, and his research focus is in the digital economy space, interviewing and working with industry to assess the need for systems that can automatically curate and contextualize information from paper records. Samuel graduated from the University of Southampton in 2018 with an MChem in Chemistry and Maths, and, prior to undertaking his recent position, he worked as a Research Technician at the University, and was involved with a variety of different projects. He led the development and implementation of a machine learning platform for the polymeric materials sector, aiding them in bringing new products to market faster. He has also developed and helped deliver a Python programming course for undergraduate chemists as well as being involved in assessing the ethical implications of implementing AI and data sharing across the food supply chain.

Justin Sacks is a doctoral researcher at Imagination Lancaster, the design-led interdisciplinary research group at Lancaster University. Justin's research utilizes speculative design to engage diverse participants in developing post-capitalist futures. Prior to starting his doctoral research, Justin developed sustainable procurement systems for organizations in the UK and internationally. Major programs still operational include the Community Benefits Measurement Tool for the Welsh Government, CAESER for the UK Home Office, and Local Multiplier 3 (LM3) used across local government. Food-related sustainable procurement projects include the Better Hospital Food Programme funded by the King's Fund and Race to the Top funded by Defra and Esmée Fairbairn Foundation.

Professor Simon Pearson is the Director of the Lincoln Institute for Agri-Food Technology, University of Lincoln. He is also the Principal Investigator of the UKRI-EPSRC-funded project, The Internet of Food Things, which is working

to reduce food waste, increase nutritional value and productivity, and reduce environmental impact across the supply chain. Simon has almost two decades of experience in management and research and development roles within the industry, and has become a leader in interdisciplinary research in the field of agri-technology by bringing together academic and industrial experts who are striving to improve technological, environmental, and human capital aspects of the food industry. Simon is part of Digital Sandwich, a project developing a national open demonstrator of a digital supply chain that will transform our understanding of the supply chain allowing manufactures and other stakeholders to reap the benefits of increased knowledge. Simon's research interests cover a diverse range of agri-technology applications, including agri-robotics systems, to drive productivity across the agri-food sector, and the automation and design for manufacture of integrated e-hubs for agricultural vehicles.