Digital collaboration in the food and drink production supply chain

Internet of Food Things
Network Plus

Foreword

This short report presents an overview of some of the ways that pioneers are exploring the digitalisation of the food production supply chain

People have always collaborated in creating, processing and consuming food. These collaboration activities are becoming ever more necessary as we respond to complex challenges such as the climate crisis and food security. With the advent of Industry 4.0, it is clear that digital technologies offer the potential to transform how we respond to this complexity.

How do we capitalise on these examples and move forward? If we can harness the enthusiasm of such innovators, we can tackle the big challenges and deliver potential solutions. At the Internet of Food Things Network Plus we will be coordinating further research, hosting workshops and publishing reports that examine in more detail the role of digital collaboration in 21st-century food supply chain.

We thank everyone who has contributed to the production of this first report, and we invite all those concerned about the future of food production to join the IoFT Network and participate in this journey.

Professor Simon Pearson, Director of LIAT, University of Lincoln, and principal investigator, IoFT Network+

Introduction

The digital revolution has impacted on all aspects of our lives and this trend is set to accelerate. Capturing and using digital data enables transactions and planning to be undertaken more quickly, more accurately and with greater confidence. New technologies, such as the Internet of Things and artificial intelligence, enable new levels of efficiency to be achieved through machines talking directly to machines. These developments offer new ways to tackle some of the grand challenges in the food production supply chain, from traceability and sustainability to reducing waste.

However, despite all these technologies and datasets, successful food and drink production and distribution ultimately come down to relationships. Trust and trustworthiness are key facets of these relationships but how trust is created, extended and eroded is a complex process. Transactions typically involve the sharing of data and information relating to the quantities, descriptions and quality of goods. While sharing this information may simplify the processing of goods, it

also requires - and is a measure of - trust. The flow of data may not directly accompany the journey of the goods: another measure of trust in relationships and the trustworthiness of processes.

In order to help prepare for the future, we thought it would be useful to examine the present: what are the dominant models in existence today supporting digital collaboration in the food and drink sector? What are the blockers to greater digital collaboration?

Based on a series of interviews conducted during spring 2019 in the UK and other European countries, we have identified a range of different digital collaboration settings, together with a number of key blockers to greater collaboration. This preliminary work enables us to set out a roadmap for the research needed to deepen our understanding of these digital collaboration settings and behaviour patterns, and explore how they may be improved to address the wider challenges inherent in the food production supply chain.

What are the grand challenges that digital collaboration can address?

From the climate crisis to cybersecurity threats, the modern food manufacturing supply chain is profoundly vulnerable in terms of the complexity, demand and uncertainty surrounding processes, sources and dependencies. It is currently facing a range of significant and interdependent challenges that require collaboration and innovation.

Traceability, transparency and disclosure

The ability to track where food has come from and what processes it has undergone on its way from farm or factory to fork is fundamental to trust in the food system. As food supply chains become ever more complex, ensuring transparency and disclosure can be complicated and costly but is essential.

Food safety and fraud

There are more than a million cases of food poisoning a year in the UK and, globally, a tenth of the world's population falls ill each year after eating contaminated food. Food fraud is estimated to affect 10% of all commercial food products, and food crime is an ongoing and increasing threat in the UK. It is estimated to cost the UK food and drink industry up to £11bn a year and the health consequences can be life-threatening. Food recalls are also wasteful.

Efficiency, productivity and sustainability

Food manufacture and distribution already consumes 15% of global fossil fuels and accounts for 28% of global greenhouse emissions. Yet we face a global shortfall in food supply and a rising population. Only a more efficient, less energy-intensive food production system and supply chain that responds to the climate crisis imperative will ensure that the world's population remains sustainably fed.

Improving diets and health

Worldwide obesity has nearly tripled since 1975 and to be lean is now a minority state of health. But we are also seeing micronutrient deficiencies. By 2045, 25% of the UK population is expected to be 65+ and poor diet is one of the biggest contributors to the number of years we spend in poor health. How do we 'add lives to years' through diet, personalised food and individual profiling?

Reducing waste

We waste approximately a third of food produced for human consumption across all of the stages of the supply chain and in the home. The impact is huge in terms of both financial cost and effect on the environment.

Digital collaboration

Collaboration between trading partners to construct food supply chains is not new[1]. Neither is the acquisition and exchange of information to support these transactions and help develop stronger trading partnerships. However, digital technologies have changed the scale of these interactions, opening up the opportunity for more dynamic and fluid relationships across the whole of the supply chain.

Digital collaboration is complex because supply chains are constantly evolving as transactional relationships coalesce, mature and fragment. Furthermore, these transformations are taking place continuously, at multiple points in longer supply chains. When data and digital technologies are used effectively they can support and speed up these processes.

We have identified four common settings in which trading partners collaborate digitally. They range in scale from the dominant example of the supermarket, representing a highly complex, strategically powerful network of trading partners, to community food hubs and data-driven food-tech startups that adopt different priorities and development timeframes for cooperation and coordination.

Within these settings there is a variety of digital collaboration practices, such as:
- Legal obligation data gathering (regulatory gathering)
- Voluntary data sharing agreements (community of practice)
- Data collection, analysis and derived insight (data-driven innovation)

	Setting	Lead actor (governance)	Data sharing	Nature of collaboration	Regionality
1	Complex collaboration: strategically powerful network of trading partners	Retail organisation (supermarket)	Closed	Transactional. Asynchronous data capture orchestrated by retailer. Selected information may be shared with suppliers.	National/regional but with international supply chains
2	Cooperative network	Community-driven network (food hub)	Open	Locally complex, small-scale arrangement. Collaborative. Various data and information sharing patterns as agreed by the communities.	Regional/local, typically with local supply chains
3	Coordinated arrangement: relatively simple structures	Trade body or ethically-driven movement	Open	Loosely coordinated. Simple mechanisms but may be at scale. Various data and information sharing patterns as agreed on behalf of the community.	International/ national/regional
4	Open market	Traditional ad hoc, data-driven disruptor start-ups	Ad hoc	Ad hoc. Data acquired by agreement and may be heavily exploited for data-driven business model in case of disruptor.	Any

[1] *An Empirical Investigation into Supply Chain Management: A Perspective on Partnerships* by Robert E. Spekman and Niklas Myhr (in Supply Chain Management, February 1998 DOI: 10.1108/13598549810215379)

Settings

1. Complex collaboration: strategically powerful network (supermarket)

The large food retailers (supermarkets) dominate the food market and are in a position to control data flows to and from their suppliers and also acquire data from their customers through loyalty cards and other forms of data capture. The diagram on page nine sets out a simplified view of the data and product flows involved in these transactional relationships.

2. Cooperative network (food hub)

The food hub concept typically describes a cooperative, community-based arrangement connecting suppliers, traders and consumers, commonly in a localised region. With an informal collaborative approach to all planning and decision-making and a concern for environmental issues, food hubs may rely on digital services to facilitate interaction and trading, presenting themselves as online farmers' markets for the digital age, such as Tamar Valley Food Hub.

A food hub case study: Bowhouse, Fife

Bowhouse, in the East Neuk of Fife, "replaces a missing link in the food chain from field to fork, from farmer to consumer" by providing dedicated space for producers to operate in as well as a large, covered market space to sell produce from, which attracts 4,000-5,000 customers once a month.

"The supply chain is so short, logistically and geographically, that you can touch it. The miller who mills flour at Bowhouse uses wheat that grows within two miles of his mill and he's surrounded by the farm that's growing it. And when you buy his flour, you're within 20 foot of where it's milled, and you can see the mill." – **Toby Anstruther, Bowhouse founder**

3. Coordinated arrangement

Egalitarian, bi-directional collaboration along a chain that may still include major retailers towards the end of the chain. These can be ethically motivated, sharing beliefs that are of value to the participants and also the wider world. Other examples are trade bodies that monitor and analyse information for a particular purpose.

A coordinated arrangement case study: Tony's Chocolonely

Tony's Chocolonely is a Dutch chocolate company on a mission to eradicate slave labour from the cocoa industry. Its cocoa beans are 100% traceable, with partners tracking their stock from plantation to the bean warehouse in Antwerp using Beantracker.

"When a sea container with cocoa beans docks in Antwerp, the manager of the cooperative will see this in the Beantracker. And he'll know that the cooperative is entitled to a premium for those beans... This way, we know exactly where, how and by whom our cocoa is being produced [2]."

Tony's Chocolonely has partnered with Accenture to pilot blockchain technology to speed up and improve Beantracker.

[2] *Tony's Chocolonely Annual Report 2017/18* https://tonyschocolonely.com/storage/configurations/tonyschocolonelycom.us/files/jaarfairslag/2017-2018/tonyjfs_201718_complete_eng.pdf)

4. Open market

As with other sectors such as music and insurance, disrupters have entered the food sector with digitally enabled paradigm-shifting business models. Through the application of data science, AI and analytics, these entrepreneurs are creating new businesses that serve consumers with new products or services they hadn't realised they needed. These include prepared menus, such as Gousto and Hello Fresh food boxes, and other personalised approaches based on data and predictive modelling.

Open market case study: data science in the recipe kit business

Gousto is one of the largest UK-based recipe kit providers, offering 40 recipes on a weekly menu. Founded in 2012, Gousto has been a digital business from its very beginning and bills itself as a tech company that happens to trade in food. Data science and data sharing are at the heart of Gousto's business model and have been built-in from the start. More than 40% of recipes ordered on a weekly basis follow data-driven recommendations on the personalised website landing page, emails and Alexa skill (voice). There is a direct line of communication with customers through social media, which Gousto uses for feedback on new recipe ideas, and there is also collaboration on the supplier side, including an annual conference with suppliers to work together through issues such as packaging sustainability.

"Gousto is a young business in a well-established space and we try to communicate how we work with data through these conferences. Our suppliers are learning along with us." – **Marc Jansen, Gousto's data scientist**

Digital collaboration practices

1. Voluntary data sharing agreements (community of practice)

This example of digital collaboration is characterised by voluntary data sharing for communal benefit. This typically occurs between organisations that are otherwise competitors and that see some professional benefit in sharing data with a third party – for example, for some kind of voluntary certification. With a high degree of trust, participants contribute data, typically to a central store of some kind, and then derived information might be extracted for benefit to the wider community. Examples include trade bodies where there is some form of certification or endorsement for the participants. Such arrangements exhibit a good degree of trust – for example, that the organising entity does not exploit the data commercially or otherwise unfairly undermine the reputation of participants.

Community of practice case study: data sharing for genetic profiling in cattle

Teagasc, the national body for agricultural research in Ireland, has a long-standing data-sharing relationship with the Irish Cattle Breeder Federation (ICBF). Farmers submit cattle data to ICBF and the database of 100 million records on 30 million animals is used for the genetic improvement of Irish beef and dairy herds. Teagasc and ICBF have been providing population-level genetic predictions around milk quality and reducing the data down to a simple figure for farmers. A website predicts the value of calves from a cow based on the bull the farmer chooses. The result has been a one to two percent increase in protein content in the national herd – increasing profits by 1.5bn euros.

Community of practice case study: halving antimicrobial use in the pork industry

The Responsible Use of Medicines in Agriculture (RUMA) is working across the supply chain and with government and industry to move forward on the crucial strategic issue of antibiotic resistance. Its use of an electronic medicines book for pigs, which produces a benchmark and then stimulates and tracks more responsible use of medicines, has halved the use of antimicrobials in the pork industry within a two year period. Now it is partnering with AHDB on a pilot of an electronic medicines book for cattle, so farmers will be able to input their data digitally into the system, directly or via software providers, where it will be collated, anonymised, analysed and used to set a national benchmark that enables individual farmers to guage their particular results against their anonymous peers. The pool of data can be used to inform the national picture and steer national strategies. Individual data is fed back to the producer who can choose to allow others to access it.

"It is a collaborative exercise, permeating the chain, that is dependent on good governance, recognition of ownership, and good curation of data, otherwise trust will be lost." **– Ray Keatinge, AHDB**

Community of practice case study: tackling predictive problems to improve efficiency

Lactose levels in milk change physically throughout the year, which affects the kinds of products that can be made from it, from infant formula to cheese. Ireland's VistaMilk Research Centre is using datasets from diverse sources, such as climate, location and specific data around the production of milk on a given farm at a given point, to more accurately predict the volume and type of milk that will enter factories at any particular time. This means that processing facilities can be better prepared for the milk they receive – saving time and money.

"That's one predictive problem we're looking at, but there's an awful lot of them across the whole of that supply chain. Some are quite local while others are more complicated and stretch further across the supply chain. The data allows us to model various influences or impacts across a supply chain on the final product that's produced." **– Professor Mark Keane, VistaMilk, University College Dublin**

"Within the supply chain there are a lot of entities and processes to be mapped out, and previously disconnected datasets can be better linked together. In food supply chains, you have everything from feed and fertiliser to customers and consumption, with all the associated data sources along the way (animals, workers, trucks, packagers, IoT devices, quality controllers, markets, and more). This will mean multiple stakeholders working together to understand how they can benefit from a shared and linked dataset."

Professor John Breslin, VistaMilk, National University of Ireland Galway

2. Legal obligation data gathering (regulatory gathering)

This is compulsory, regulatory gathering of data from which information is created for societal benefit. Regulatory bodies such as the Food Standards Agency have a legal right to collect data from businesses operating in the food and drink sector. Some information extracted from this data will be shared directly with individual businesses and other information, such as food hygiene ratings made public.

Regulatory gathering case study: abattoir compliance

The UK Food Standards Agency (FSA) is leading the way within government in real-world applications of distributed ledger technology (DLT). The agency has successfully completed a pilot using DLT in a cattle slaughterhouse – the first time it has been used as a regulatory tool to ensure compliance in the food sector. In the pilot, both the FSA and the slaughterhouse had permission to access data, giving the benefit of improved transparency across the food supply chain. DLT is expected to remove laborious tasks, add value to collected data and, ultimately, influence farmers' management practices to improve quality.

Regulatory gathering case study: bovine disease control in Ireland

Bovine viral diarrhoea has been almost eradicated in southern Ireland thanks to a data sharing initiative. Lab data from the compulsory testing of animals goes to the farmer and into a central system. Through that central data repository, each animal's disease status is flagged up when it comes to market and is shared widely with any buyer around the ring. The system is backed up by legislation as farmers are forbidden to sell any animal known to be persistently infected.

3. Commercially required data sharing

This form of involuntary data sharing relies on commercial power rather than a regulatory imperative and includes supermarkets' requests for data from their suppliers.

Commercial imperative case study: tracking whisky from bodega to distiller

International premium spirits company Edrington owns the forests in Spain from which the wood is taken to make its whisky barrels. The barrels are seasoned with sherry or wine at bodegas for three years before being shipped to Scotland to be filled with whisky. Wood is an expensive commodity within the whisky supply chain and barrels are reused at least twice. However, without data from its suppliers Edrington was unable to track with any real certainty the barrels that had produced exceptional whisky in order to use them again. Improved data sharing along the chain from bodegas and cooperages in Spain to distilleries in Scotland, with a lifespan tracker for the whisky barrels, has allowed Edrington closer scrutiny and quality control.

4. Data collection, analysis and derived insights (data-driven innovation)

Digital collaboration is enabled through a combination of hardware technologies such as IoT, cloud computing, telecommunications (most recently 5G) and robotics, coupled with data. Digital collaboration is further enhanced through data science – the art and science of extracting actionable insight from data. Whereas data sharing in a community practice directly benefits all those involved, here the management and exploitation of data is for the primary benefit of the business involved (although it might also have wider societal benefits, depending on the organisation's mission).

Data-driven innovation case study: tracking and tracing meat for food safety

Most of the transactions between farmer and slaughterhouse, slaughterhouse and meat processor, and meat processor and retailer are done manually. Trackt is a Benelux-based startup offering a blockchain-based platform aiming to improve tracking and tracing through Internet of Things devices and distributed ledger technology. Temperature control during transportation can be better managed, leading to improved food safety and a reduction in waste as it becomes easier to pinpoint specific shipments where the temperature may have breached safe levels, avoiding the recall of a whole day or even week's worth of meat.

"Right now, it takes 48 hours to determine where the meat came from, using a lot of manual processes. Trackt and blockchain will reduce that to 10 seconds." – **Marc de Thouars, Trackt**

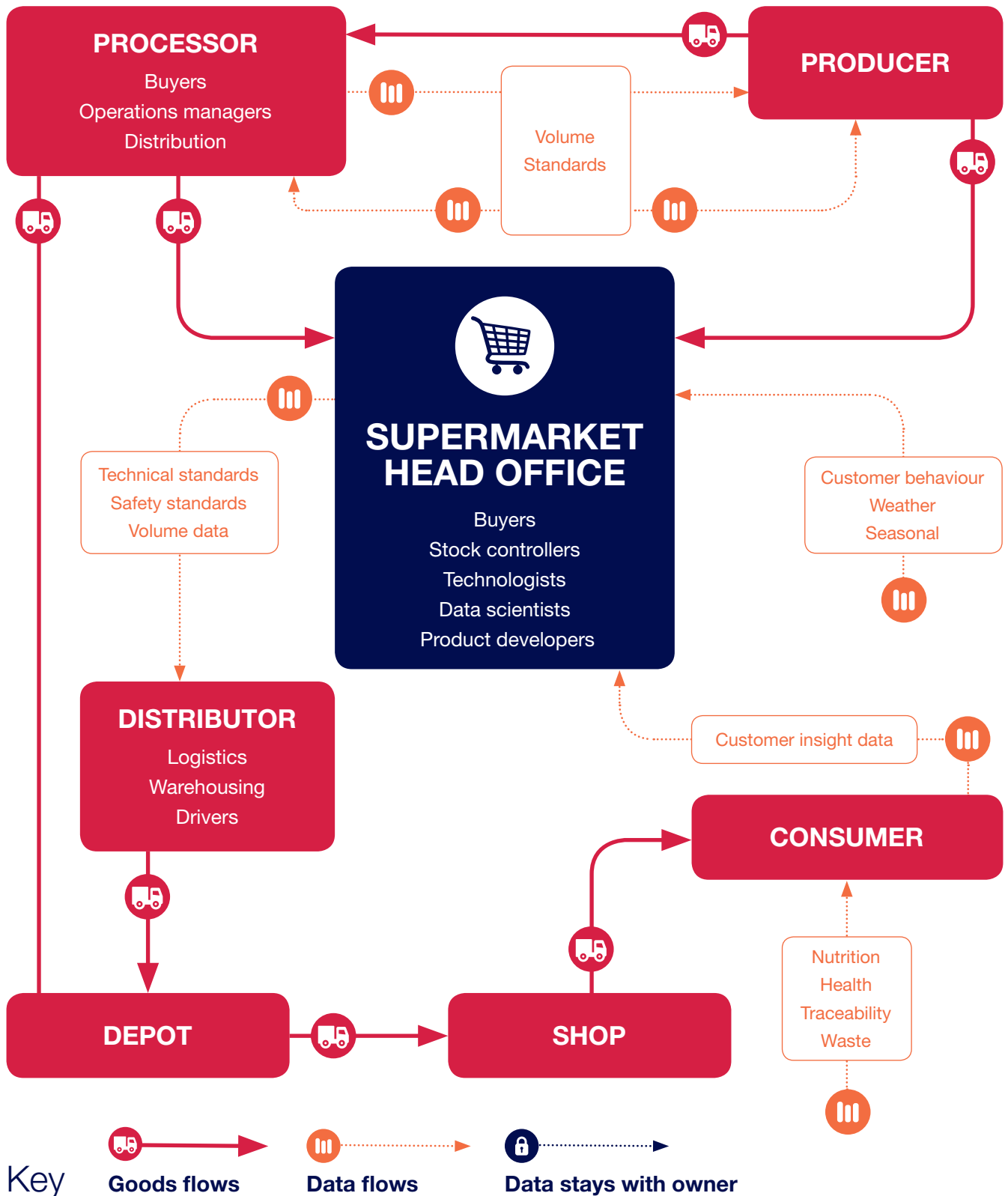### Data-driven innovation case study: reducing waste

Ozarka is an Amsterdam-based circular economy start-up that aims to take single-use plastic out of the environment as much as possible. The business replaces throwaway plastic takeaway food containers with reusable return-for-deposit containers that can be used hundreds of times. To do that, it needs a flow of data.

"Our model will only appeal to the most niche hardcore environmentalists if we can't make it trivially easy for people to participate. In order to do that, we need very sophisticated models and robust datasets that can show us everything from customer movement patterns, how those patterns are affected by time of day, traffic, weather, all the usual suspects, in order for a customer to take that moment when they've got a reusable box in their hand and make it inconsequentially easy for them to return that box and get a refund on that deposit. We come from data-driven backgrounds and we see data as the best and only opportunity for us to create a customer experience that we'll successfully scale." – **Beth Massa, Ozarka**
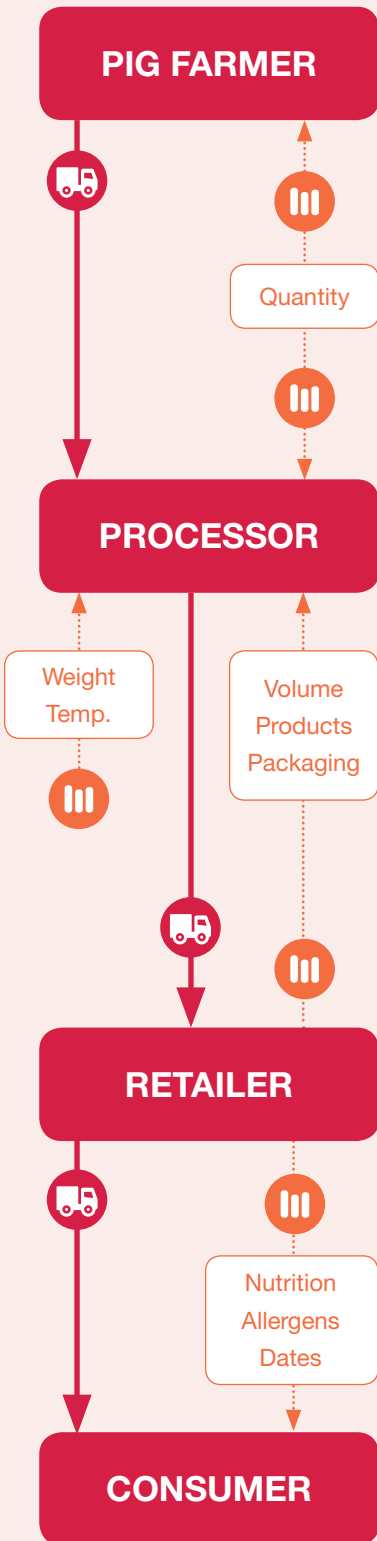
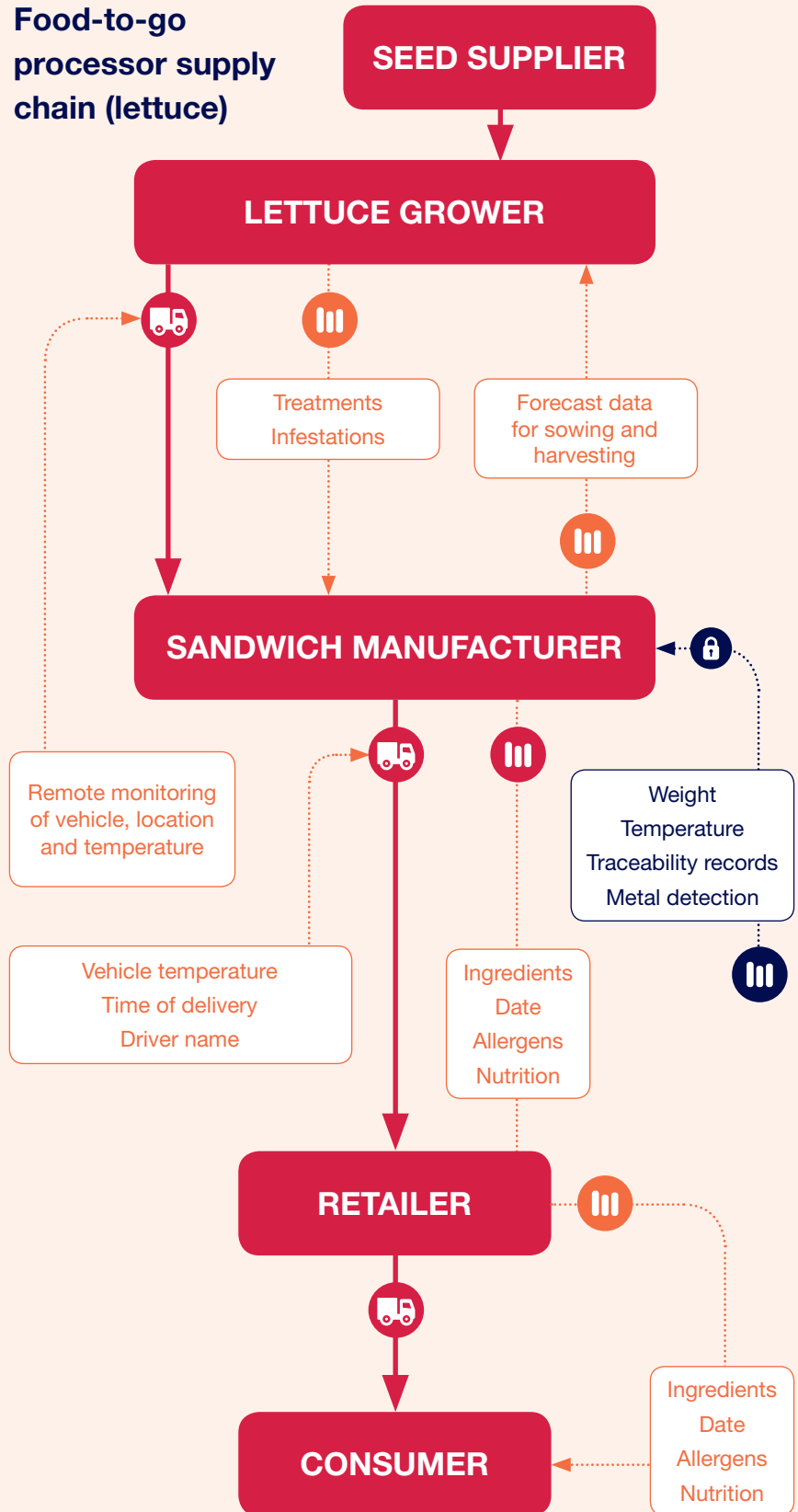# Product and data flows in the supermarket supply chain ecosystem

Primary supply chain

PROCESSOR
Buyers
Operations managers
Distribution

PRODUCER

Volume
Standards

SUPERMARKET
HEAD OFFICE
Buyers
Stock controllers
Technologists
Data scientists
Product developers

Technical standards
Safety standards
Volume data

Customer behaviour
Weather
Seasonal

DISTRIBUTOR
Logistics
Warehousing
Drivers

Customer insight data

CONSUMER

Nutrition
Health
Traceability
Waste

DEPOT

SHOP

Key
Goods flows   **Data flows**   **Data stays with owner**

Meat processor supply chain

PIG FARMER

Quantity

PROCESSOR

Weight
Temp.

Volume
Products
Packaging

RETAILER

Nutrition
Allergens
Dates

CONSUMER

Food-to-go processor supply chain (lettuce)

SEED SUPPLIER

LETTUCE GROWER

Treatments
Infestations

Forecast data
for sowing and
harvesting

SANDWICH MANUFACTURER

Remote monitoring
of vehicle, location
and temperature

Weight
Temperature
Traceability records
Metal detection

Vehicle temperature
Time of delivery
Driver name

Ingredients
Date
Allergens
Nutrition

RETAILER

Ingredients
Date
Allergens
Nutrition

CONSUMER

What is standing in the way of digital collaboration?

Through our interviews we identified a number of inhibitors to greater digital collaboration. These ranged from the purely technological – such as poor connectivity in remote areas preventing farmers adopting more digital ways of handling data – to challenges that had a greater relationship with skills, mindsets and collective culture than a technological deficit.

HIGH

TECHNOLOGICAL

Poor telecommunications connectivity in remote areas

Lack of interoperability between systems

Cybersecurity risks and threats

Discoverability of existing datasets

Data overload

Governance

Public distrust

Personal data rights and responsibilities

Policy alignment

Data ownership and commercial sensitivities

Differences in capabilities between participants

Trust and transparency

Lack of interdisciplinary teams

Knowledge skills gap

Individual mindsets and collective culture

LOW

LOW — SOCIAL — **HIGH**

■ Technological related   ■ Social related

What might help?

A social approach: data trusts and platform co-ops

The various collaboration settings and practices that we have seen suggest some interesting new governance arrangements – from food hub cooperatives to ethically driven audit schemes and not-for-profit trade bodies. Can these be replicated on a larger scale? One potential governance mechanism gaining interest is that of the data trust: proven and trusted frameworks and agreements to facilitate the sharing of data between organisations, that may include independent stewardship of data. The UK government's Office for AI partnered with the Open Data Institute (ODI) to explore the potential role for data trusts. The pilot projects included a study of food waste to assess how a data trust might help to connect food waste data to other datasets.

There is currently an emergent understanding of what the data trust concept means and as more examples of data trusts are developed this understanding will inevitably evolve. It is likely that there is not one single, simple solution. For example, the rise of the platform co-op, a cooperatively owned, democratically governed business that establishes a computing platform and uses a website or app to facilitate the sale of goods and services, offers an alternative vision.

A technology approach: distributed ledger technology / blockchain

Distributed Ledger Technology (DLT), or blockchain, is a consensus of replicated, shared and synchronised digital data, geographically spread across multiple sites, countries or institutions. There is no central administrator or centralised data storage. Specific supply chains can be connected to a DLT platform and then immutable records can be captured throughout the lifetime of the supply chain for the mutual benefit of all actors in that chain.

DLT is being explored in the food and drink industry in response to the traceability challenge. The UK Food Standards Agency (FSA) has developed two proof of concept DLT services for pork and cattle, Walmart China has launched a DLT-enabled traceability platform for consumers and start-up Provenance is seeking to open up supply chains using its DLT model.

IBM's Food Trust product, which uses DLT to connect growers, processors, distributors and retailers, is being used in the French and Chinese stores of the Carrefour supermarket chain.

"A data trust is a legal structure that provides independent stewardship of data."
Open Data Institute (2019)

"Using blockchain would transform the food industry. Not only would it make the process of traceability much quicker and easier, it would also allow other digital technologies to be fused together, such as the digital twin, permitting a smarter, more transparent, more accurate, less wasteful supply chain. Ultimately it will have a significant and positive impact on food safety, sustainability and productivity for our industry."
Tom Hollands, innovation and technical director, Raynor Foods

Actions

Key questions need to be explored:

We have investigated a range of examples of digital collaboration through interviews and these have suggested a handful of data sharing settings and practices, some more prevalent than others. Based on this information and existing research literature, we have framed a series of research questions which address these findings in the context of the grand challenges presented at the start of the report:

1 Can we identify a collection of discrete models to represent digital collaboration in these observed settings and practices?

2 How can the trustworthiness of organisations and data sharing models be determined and what encourages or inhibits willingness to share data?

3 What is the impact of digital collaboration on power relationships and value capture in the traditional food production supply chain?

4 We have presented a simple diagram that attempts to capture flows of products and data. If this was further developed, how would we represent value creation, value capture and, more challengingly, trustworthiness?

5 Various data management technologies are emerging as innovation drivers, including blockchain and distributed ledgers, but how can we ensure the veracity, relevance and significance of the data and information captured with the systems?

6 The general public and politicians are becoming more concerned with the ethical dimension of the food production supply chain. To what extent can data demonstrably address these concerns?

7 Integrating food industry and health sector data in such a way that government, external bodies and other citizen representatives gain actionable insights will require complex management of trust relationships. How might this be achieved?

Further research activity is now needed to deepen our understanding of the settings we identify in this report, the practices around them and how they might be improved to address the wider challenges inherent in the food production supply chain. The Internet of Food Things Network Plus will be in a position to fund such research. Other funders will also be able to develop these ideas.

Conclusion

This report presents a snapshot of the landscape of digital collaboration activities in the food supply chain across the UK and our near neighbours. There is clearly evidence of diverse useful practices across the landscape and, in a handful of cases, significant innovation which has the potential to disrupt the sector. We have also identified a host of barriers to such innovation.

To progress further and faster, strategic thinking is required to develop the approaches needed to reap the benefits of digital collaboration. Communication of the vision, behaviour change at individual, community and societal level and governance mechanisms are all needed if greater digital collaboration is to become one of the tools used to address the complex challenges facing the food production and supply chain.

Successful food production depends on a critical mix of husbandry, manufacturing processes, storage and distribution. We have seen evidence of more cooperative, ethical, ecologically aware and healthier approaches, all of which can be enhanced, expanded and transformed with the help of digital collaboration practices. We have proposed that further focused research, funded by the Internet of Food Things Network Plus and others, can contribute to both swifter progress, and a strategic approach that integrates with other strategies for food, data and manufacturing for the future.

Acknowledgements

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