DIGITAL FOOD

Briefing document:
digital technologies for improving productivity in food manufacturing

Internet of Food Things Network Plus

CENTRE FOR SMART SUSTAINABLE MANUFACTURING AND RECYCLING TECHNOLOGIES

Contents

We would like to offer our sincere gratitude and appreciation for the valuable insights provided by all those who have contributed to the generation of this report, particularly speakers and companies who provided data for and review of this document. This report does not necessarily reflect or endorse the policy positions of the individual organisations present at the '*Digital technologies for improving the productivity in food manufacturing*' meeting.

Foreword

The UK food manufacturing industry is the largest manufacturing sector in the UK, contributing over £28.2bn to the UK economy. Actors across the food manufacturing supply chain are evolving their practices to reduce waste, meet the food security challenge and address changing consumer needs, aided by the emerging technologies of the Fourth Industrial Revolution (Industry 4.0). While such improved connectivity promotes greater collaboration and customer service, it also presents new challenges and obstacles.

The Centre for Sustainable Manufacturing and Recycling Technologies (SMART) and the Internet of Food Things (IoFT) Network Plus are working to address these challenges, to encourage and enable the wide-scale adoption of digital technologies across the UK's food sector.

Taking advantage of digital technologies is vital to the prosperity of UK food manufacturing and requires immediate action. This report underlines the numerous possibilities digital technologies offer to the UK's food manufacturing sector and confirms the industry's need for a collaborative approach to the adoption of these new technologies. Implementing a transition to Industry 4.0 requires the involvement of players from across the supply chain, academia and government and a change in mindset from 'nice to have' to 'must have'.

The purpose of this report is to provide actionable insights in support of these next steps for incorporating the opportunities offered through Industry 4.0. These opportunities are discussed under three lenses: real time resource efficient production, resilient and productive food supply chains, and the use of digital technologies for improved consumer engagement.

At the Centre for SMART and IoFT we look forward to hearing from stakeholders across the food supply chain on your plans and proposals in support of these next steps.

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Digital food: the three lenses

On 2 April 2019, the Centre for Sustainable Manufacturing and Recycling Technologies (SMART) and the Internet of Food Things (IoFT) Network Plus hosted a conference, '*Digital technologies for improving the productivity in food manufacturing*'.

The event brought together more than 50 industrial leaders, professional bodies and academics in a workshop-style meeting to identify next steps for the uptake of digital technologies across the food manufacturing supply chain. The opportunities were discussed under three lenses.

This report aims to provide a balanced analysis of the evidence presented at that meeting and actionable insights to inform policy and practice.

LENS 1
Real-time resource efficient production

Technology is making food processing and manufacturing smarter, improving efficiency and reducing waste

LENS 2
A resilient and productive food supply chain

The return on investment in digital technologies and their benefits to the coordination of an end-to-end supply chain

LENS 3
Digital technologies to improve consumer engagement

Digital technologies address changing consumption patterns and help businesses adopt new business models

Introduction

The UN's Food and Agriculture Organisation (FAO) has recently highlighted that 50-70% more food must be produced by 2050 to meet the needs of the growing population and changing dietary demands. Studies also emphasise that over the past 40 years climate change has caused the loss of a third of the Earth's arable land and that roughly one third of food produced globally for human consumption is wasted.

In this context, global food security requires immediate and substantial social, economic and industrial reform to alleviate the strain on natural habitats and current food supply chains. Players across the food manufacturing supply chain must evolve their practices based on the opportunities offered through Industry 4.0 and associated digital technologies to address chronic global productivity challenges.

Recent studies[1] have outlined the advantages these digital technologies will bring to UK food manufacturing.

Consequently, current UK investments and initiatives such as Made Smarter, the Food and Drink Sector Council, the Food and Drink Federation, Defra's Resources and Waste Strategy, and the Food Standards Agency are striving to bring about the digital evolution needed to improve productivity of the food sector.

Following the consultation of the meeting's attendees, a number of innovative ideas and significant views were developed which led to the generation of this report, so industrial leaders, technology developers, professional bodies, government officials and academics can take the steps necessary to transform the UK food manufacturing supply chain's sustainability and resilience.

As the largest manufacturing industry in the UK, the food industry can pave the way for greater adoption of sustainable practices by all the nation's manufacturing sectors.

1. Transformative Innovation Across Food Supply Chains to Improve Decision Making (www.foodsecurity.ac.uk/publications/transformative-innovation-across-food-supply-chains-to-improve-decision-making.pdf); The Food and Drink section of the Made Smarter Review 2017; The Courtauld Commitment 2025

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SUSTAINABLE MANUFACTURING AND RECYCLING TECHNOLOGIES

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DIGITAL TECHNO
IMPROVING PRODUCTIV

LENS 1

LENS 2

LOGIES FOR
NITY IN FOOD MANUFACTURING

CLOSING COMMENTS

CULTURE NOT TECH WILL ENABLE SECTOR LEADERSHIP

EXPERIMENTATION MINDSET NEEDED

WASTE REDUCTION DRIVING FACTOR

DATA SHARING CRUCIAL, NEED TO OVERCOME BARRIERS

TRUST NEEDS TO BE BUILT + PROTECTED

CONTINUAL RESKILLING NEEDED AT ALL LEVELS

POLICIES NEEDED TO CO-ORDINATE DATA STANDARDS

STEVE BREWER
IoFT NETWORK PLUS

GLOBAL SUPPLY CHAINS

PRODUCTS FROM ALL CORNERS OF THE WORLD

INNOVATION WORKGROUP

IMPROVE SOLUTIONS TO PROBLEMS

INVESTMENT STRATEGY

LOW FORECASTING

SPATIAL

ATEGY

G EXISTING NOLGY TO ROVE

BARFOOTS

KESTON WILLIAMS

LENS 3

SIMPLE MODEL

CUSTOMER DRIVEN

ZERO WASTE

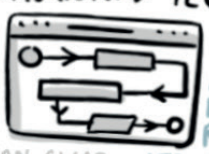
£100 MILLION COMPANY

OUTSOURCE LOGISTICS

2019 MENTALITY

40% OF ALL RECIPES ORDERED FOLLOW DATA DRIVEN RECOMMENDATIONS

OLD FASHIONED TECHNOLOGY LAYERED



ALGORITHMS KEEP BUSINESS RELEVANT TO ITS AUDIENCE

CAN SWAP OUT INGREDIENTS

150 EMPLOYEES LONDON

350 WAREHOUSE

BALANCING ACT BETWEEN LEADING CUSTOMERS & CUSTOMER LED

MARC JANSEN
GOUSTO

DIRECT CONTACT WITH CUSTOMERS THROUGH PERSONAL TECHNOLOGY

MANAGING PERSONALISATION PORTFOLIO

- ADVANCED ANALYTICS
- IMPLEMENT SENSORS

CHALLENGES OF SUPPLY CHAIN PLAN, PLAN, PLAN!!

MARKET IS WIDE OPEN

FRAGMENTATION OF CUSTOMERS

NEED TO ADAPT

MONITORING ONLINE HABITS

UNDER SCRUTINY FROM CUSTOMERS ON SOCIAL MEDIA

ESPECIALLY WASTE + SUSTAINABILITY

MACHINE LEARNING

MAJORITY OF STAFF AGED 35-50

UNILEVER

NEED TRAINING + SKILLS

DAVID SPRENT
GLOBAL SUPPLY CHAIN

natalka design

Lens 1 – Real-time resource efficient production

Technology is making food processing and manufacturing smarter and improving efficiency and reducing waste

The Made Smarter review (2017) identified a £55.8bn opportunity for the food and drink sector over the next 10 years through the adoption of currently known digital technologies. As a result the sector has been asking some pressing questions. How can technology improve resource efficiency and reduce food waste? How does the agri-food sector become more efficient? How can more jobs be automated in the produce sector where labour availability is a problem? How can duplication of effort in the supply chain be reduced? How can the mountains of paper in the supply chain be digitised?

The emergence of the smart food factory offers a significant opportunity to tackle some of these questions in the production sphere. Sensor technology, image recognition and connectivity via IoT are driving further automation. With automation comes greater efficiency, improved hygiene and traceability, and increased consistency. While these technologies can help to reduce costs, arguably more important is their contribution to managing complexity, controlling operations and improving responsiveness. Digitalisation can secure organisational competitive advantage and enhance the UK's competitiveness.

Several tools including Internet of Things and robotics, drawing on artificial intelligence, are greatly assisting food processors and manufacturers to improve resource efficiency and reduce waste. While these are only two of the many technologies available to assist production, the adoption of new technologies is not rapid because industry is struggling with a lack of skills, the cost and complexity of integrating these tools, the need to digitise data, and older cost models that do not accurately reflect the ROI for the uptake of digital technologies.

LENS 1 CASE STUDY

Edeka: one of the most digitalised food factories in the world

Edeka in Rheinstetten is a meat processing plant for Germany's biggest supermarket and one of the most digitalised food factories in the world. Operational since 2011, it produces around 650 tonnes of meat a day, creating around 2500 sales items for delivery to 1,250 Edeka stores.

Edeka, facing continual competition to be more efficient and cost effective than its rivals, set out from the start to build the most modern and efficient factory possible. The premise was that it is not enough to simply physically automate processes. In order to reduce labour costs, they need to be truly digitalised.

"Many of these technologies have existed for a long time but what is different about this factory is that it has been built from the ground up with full digitalised production in mind," says Mathew Simpson, area sales manager, UK and Ireland, of CSB-System. "CSB was involved from the beginning to design and install the software Edeka would need to capture data in real time."

That software is the food specialist enterprise resource planning (ERP) system the factory relies on for planning, controlling and optimising all resources. The system controls the entire production chain from the arrival of goods, cutting, production planning and control to packaging, labelling, stock placement and removal, picking, loading and despatch.

It gives Edeka real-time visibility of the production chain. Two control stations permanently monitor 800 individual processes. The carcass weight is immediately and directly captured as soon as it enters the plant – ensuring that the correct amount is being paid for the product. CSB-Image-Meater® photographs the pork half carcass and measures critical muscle and fat depths in order to estimate the lean meat percentage of the carcass and key primal muscles. CSB has developed algorithms to determine the most efficient use for that carcass based on its unique distribution of muscle and fat. The graded carcass can then be streamed accordingly and this yields significant marginal gains over the course of the year.

Product is tracked every step of the way with barcode scanning so planners can see what stock they have in real time and check the progress of order fulfilment. This helps them to make more efficient plans for the next day. On the inventory side, there is automated management and control of high-bay storage and picking at the end of the line.

Planning is critical for efficient order fulfilment and is essential for traceability, explains Simpson.

"A lot of product efficiency can be driven by better planning, which is really quite difficult when new sales orders are constantly coming in and you have to plan around batches and labour shifts which are not as easy to change. In a paper-based system the planner will often physically go down to the factory floor to check on progress as they cannot tell from the office what orders have yet been fulfilled. They are forever chasing information and that's the worst thing for planning production. What you want in production is to plan as far out as possible and have the longest production run possible."

The need for paper records at the Edeka factory has been practically eliminated by real-time digital data capture, reducing the risk of human error and speeding up retrieval processes. All inputs to a process are scanned and confirmed directly on an industrial PC so that traceability and stock positions are updated instantly.

Output at the factory is higher than the two factories it replaced due to the improved efficiency and reduction in waste which has resulted from the digitalisation.

Lens 2 – A resilient and productive food supply chain

The return on investment of digital technologies and their benefits to the coordination of an end-to-end supply chain

Data is critical to the effective management of the food supply chain. Digital technology means that the information that has always been collected and recorded on paper can now be collected more quickly, accessed more easily and shared more effectively. As the Made Smarter review notes, "these technologies could revolutionise the way that supply chains operate. They could facilitate a transition from current linear supply chains (with limited use of data and new technologies) to a digitally connected supply chain network driven by connectivity and the rapid use of data."[1]

However, adapting these technologies to the industry necessitates engagement across the sector. There are policy considerations and a need for training and tailored support. Strategy development is critical and industry leaders need to be better informed about the options and benefits of digital technologies.

Distributed Ledger Technology (DLT) is one of a variety of technologies that has the potential to transform supply chains. However, to realise the potential of these technologies, industry needs the security of agreements on data sharing standards and governance.

2 Maier, J. (2017) Made Smarter. Department for Business, Energy and Industrial Strategy.

LENS 2 CASE STUDY

How Barfoots is using satellite technology to track asparagus crops in Peru

Barfoots is a 40-year-old, £165m-turnover business bringing fresh produce from 29 countries to a central hub in the UK where it is packed and sent to multiple retailers. It handles a complicated supply chain with a short shelf-life product but still achieves a 99% delivery service level.

Barfoots has been experimenting with using satellite technology to monitor crops in the field as well as tracking the containers in which the produce is transported. It is using Sentinel-2 satellites, part of the world's most sophisticated satellite observation fleet, which is managed under the Copernicus programme and funded and operated by the European Space Agency and the European Commission.

Cameras on board the satellites map the earth in incredible detail and provide precise details of the areas where Barfoots farms. They record highly detailed imagery of vegetation, soil and water cover, inland waterways and coastal areas.

Satellite images of crops can help to identify, at a glance, how lush or dry the land is, how productive the crop is and how it's changing over time. It can also reveal how farming is impacting habitats.

Barfoots is one of the largest importers of Peruvian asparagus into the UK and, by tracking the crop in Peru as it grows and interlaying the images with weather data, Barfoots can forecast how an asparagus crop will grow in a few months' time. That opens up the opportunity to look at asparagus crops globally and predict how they will be affected by climate change. Barfoots plans to extend the experiment beyond asparagus to other crops.

"With the crop data, the models allow us to analyse where crops are likely to grow best and show how climate change is evolving crops," explains Keston Williams, technical director at Barfoots. "We can look at different places and assess risk. For example, the data shows that Argentina is an area of opportunity while Senegal offers a response to challenges that Kenya has been having with big rainfalls. The data does provide some answers."

Barfoots is also using satellites to monitor its Peruvian asparagus crops' journey to the UK. Whereas asparagus has traditionally been transported by air, Barfoots took the decision to use sea freight in an effort to reduce the company's carbon footprint. However, the sea journey from Peru to the UK takes around three weeks, rather than the two or three days by air, and the asparagus needs to be monitored to ensure that it arrives in a healthy state to pack and sell.

"We worked with the Satellite Application Catapult in Harwell to develop and design a system to monitor conditions such as oxygen, carbon dioxide, the temperature and humidity in the containers in real time. We can also track where the container is and when it will arrive. If there's a problem we can intervene quickly. As well as reducing our carbon footprint, it also helps to reduce food waste," says Williams.

Keston Williams, technical director, Barfoots

Lens 3 – Digital technologies to improve consumer engagement

Digital technologies address changing consumption patterns and help businesses adopt new business models

As customer bases fragment, new channels open and products proliferate, personalisation and customisation offer new opportunities to recruit and retain customers. Improved consumer trend monitoring to assist in the development of new products, such as through point of sale data analytics and social media analytics, adds to the rich potential in this area. Effective design starts with consideration for the customer and the demand.

Localised distribution, larger factories becoming smaller factories, retailers doing some of the production at point of sale and kitchens becoming factories of the future are all part of the changing landscape. The notion of 'a product' has become more ambiguous and consumer engagement is in connection with product attributes rather than relating to all the products. Co-creation with consumers offers new opportunities for engagement but is currently not used enough.

While some technologies – like machine learning capabilities, advanced data analytics and sensor technologies – help companies to more efficiently and effectively adapt to changing consumer demands, there is a reluctance, particularly on the part of traditional product developers, to use these technologies because they want updated safety controls and measures, especially for food safety.

LENS 3 CASE STUDY

Recipe kit provider Gousto is built on data

Gousto is one of the UK-leading recipe kit providers, offering 40 recipes on a weekly menu. It has 150 people working in London (with 60 to 70 in tech) and 350 in its warehouse in Spalding. 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. From the outset the company recognised a nationwide shift in how people do grocery shopping and the opportunity to pursue the most convenient solution possible – a cardboard box with fresh ingredients and a recipe card – by leveraging technology.

Gousto owns its e-commerce front end and runs its pick-and-pack operation in its own fulfilment centre but does not do its own logistics. Gousto's margins are high because it is built on a concept of no food waste.

"Gousto's whole business concept is founded on sustainability," explains Marc Jansen, the company's data scientist. "Firstly, it is sustainability by design in the home. We provide pre-portioned ingredients so that no food is wasted domestically. Secondly, because we own our operations we can control our own waste and we forecast for this at a precise level internally. We inverted the supermarket model of putting 20,000+ SKUs in one place and keeping everything stocked to the brim, which inevitably leads to waste. We work on 2-300 SKUs a week, depending on the menu, and have exceptionally high turnover on those ingredients. Finally, we can tailor the packaging to the order and have pledged to reduce plastic in boxes by 50% by the end of this year. We are switching packaging, reducing packaging and changing the insulation."

Data science and data sharing are at the heart of Gousto's business model and have been built-in from the start. Gousto enjoys a wealth of customer data – it knows its customers' transactions, where they click and what they say on social media. More than 40% of recipes ordered on a weekly basis follow data-driven recommendation. Algorithms decide what customers see each week on the website landing page and via emails. The recommendation engine also goes beyond the website and app, encompassing email and Alexa skill (voice). Retention is the goal.

Gousto uses the power of the front end to control the back end, putting software on top of the hardware in its one factory. Leveraging consistent customer order patterns helps streamline slotting and routing in its fulfilment centre, making it more efficient. For example, some recipes are very frequently chosen together while others aren't at all and this knowledge can be factored in when optimising the pick faces. Shorter paths mean higher throughput: +90% in 18 months through AI alone. Gousto looks at customer data and uses it to influence how it runs its factory on a day-to-day basis.

"We use advanced optimisation techniques to run through billions of solutions in an automated way and on a frequent basis in order to find the best possible solution for us," says Jansen.

For Gousto, customisation is the counterpart to personalisation and a key concern is to encourage customers to interact in a more direct way. The company is on "a journey of customisation," says Jansen, by seeking to give customers as much flexibility as possible to meet their individual requirements, such as swapping ingredients or upgrading their protein choice. Families are a particular focus, with requests for family meals that can be customised to be more or less spicy for different members of the family.

There is a direct line of communication with customers through social media and Gousto uses those channels for feedback on new recipe ideas as well as working with social media influencers such as Joe Wicks, which enables dialogue with large audiences throughout the UK.

There is also collaboration on the supplier side. Gousto is working directly with suppliers to reduce packaging waste, such as working with an egg packager to remove plastic from its boxes. Gousto has an annual conference with suppliers at Spalding to work together through these issues.

"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," says Jansen.

Current challenges

Existing difficulties are hindering the adoption of current technologies, including

1. **Skills:** there is currently a lack of technical ability at all levels and uncertainty over how to attract young people with digital skills to the sector and how to reskill and upskill the current workforce.
2. **Cost and complexity:** uncertainty over the cost and effort necessary for replacing manual infrastructure linkages across the supply chain.
3. **The paper mountain:** while data exists, many SMEs currently keep their information on paper, making digitisation a challenge.
4. **Business models:** current cost models do not reflect the possible savings achieved by using new digital technologies nor do they accurately measure the ROI.
5. **Data standards and security:** lack of agreed and regulated structure for data standardisation across the supply chain as well as insufficient trust and collaboration for organisations to feel protected in sharing their data.
6. **Mindset:** there is lack of experimental and innovative mindset in testing and adopting digital technologies.
7. **Food safety:** while the Food Standards Agency (FSA) attempts to keep track of food factories, new types of players are entering the supply chain that must be monitored and controlled.
8. **Cross-sector learning:** food is much more challenging than other sectors because of its particular attributes, making it difficult to adopt digital technology best practices from outside the sector.
9. **Communication with consumer:** current methods for conveying essential information about food products to consumers are inadequate.

Actionable insights – next steps

The following list of actions were derived from the involvement and consultation of the 50 industry, policy and academic experts at the 2 April SMART and IoFT event.

1	Increase opportunities for training and education not only for the development of new digital technologies in the food sector but also in enabling the current workforce to use innovative digital tools.
2	Public investment in digital and wireless infrastructure to build capacity and capability to support the effective and inclusive implementation and use of digital technologies.
3	Actors across the supply chain need to be incentivised through strategic investment and policy intervention to adopt digital technologies to reduce paperwork.
4	Generate new cost benefit analysis tools to promote innovative business models that maximise on the new capabilities offered through digital technologies.
5	Develop common standards in taxonomy for data sharing, security, access and storage.
6	Generate peer benchmarking information and knowledge on increasing productivity, reducing resource consumption and waste generation through the adoption of digital technologies.
7	Create new food safety, quality and traceability standards based on the capabilities of new digital technologies.
8	Establish cross-sector partnerships for knowledge sharing on best practices to harness the potential of big data analytics for process optimisation and new food product development.
9	Develop user friendly cost-effective digital tools to support much needed behavioural change to improve sustainable food consumption.

At the Centre for SMART and IoFT we look forward to hearing from stakeholders across the food supply chain on your plans and proposals in support of these next steps.

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