

Agri-food firms' attitude toward digital data exploitation in the product development

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THE AIMS OF THE PAPER

This paper explores digital data exploitation behaviours and shows how these conducts change according to the data sources used by agri-food firms when developing their products.

METHODOLOGY

We adopt an exploratory multiple-case study to provide a theoretical framework for agri-food firms utilizing digital data for product development.

MOST IMPORTANT RESULTS

The article shows two prominent firms' behaviours that we labelled data explorers and data receivers and a third behaviour which is a combination of the main ones.

RECOMMENDATIONS

This article offers guidelines to support agri-food firms to distinguish how such firms may benefit from the digital transformation by gaining competitiveness improving production efficiency and supporting the development of their products.

Keywords: digital data, digital transformation, food processing, product development

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INTRODUCTION

A truck arrives at a food processing company to deliver the raw materials. A warehouse worker, equipped with pen and paper, takes note of the types of goods, their weight, quantity, and quality. Then, for each step of the food processing, the employees, again with pen and paper, write down sampling data that eventually they will send to a collecting point. In an office, a pile of papers waits for someone who digitalises those data to be analysed for producing information. This short story illustrates a characteristic context in which some food processing firms collect data to monitor and be informed about their food production. Regardless of the hard work and good intentions, these firms deal with high data collection costs, waste of time, poor data quality (affected by human errors), and lack of information. Just crossing the street, another food processing firm receives the raw materials. A weight scale generates a barcode and an ID for each good lot to which the data created during the entire food processing will be systematically attached. Thanks to the internet of things (IoT), each machinery employed for food production captures data directly in digital format at its inception and sends the data straight to a central information system. Such data are ready to be analysed and converted into information about the food production process.

These cases are emblematic of the digital transformation which is dramatically changing the face of the economy (Matzler *et al.* 2018). Digital transformation is the *application of new technologies [...] [which] requires skills that involve the extraction and exchange of data as well as the analysis and conversion of that data into actionable information.* (Schallmo *et al.* 2017, 4). Previous studies on technological innovation and food production (Beckeman *et al.* 2013, Grunert *et al.* 2008) one hand, have significantly explained how agri-food firms use technologies (e.g., Beckeman *et al.* 2013, Grunert *et al.* 2008). They also showed what new products an agri-food firm could develop (e.g. Leek *et al.* 2001, Marette *et al.* 2009, Steenis & Fischer 2016) and food buying habits (Garai-Fodor – Popovics 2021, Keller – Huszka 2021). Nevertheless, on the other hand, they missed the opportunity to investigate the increasing availability of digital data in the agri-food sector and how the information gathered by the elaboration of digital data can foster product development (Schweitzer *et al.* 2019). This gap inspires our research question: how do agri-food firms exploit digital data to develop their products?

This article contributes by empirically demonstrating that digital data exploitation behaviours change according to the data sources employed by the firms when trying to develop their products. Our paper is structured as follows: firstly, we argue for the effects of digital transformation and the use of digital technologies in the agri-food industry; secondly, we display the methodology that was adopted to conduct the study; then, we thoroughly discuss the key findings; finally, we conclude with the discussions, research limitations, and some implications for practitioners and future research.

**DIGITAL TRANSFORMATION
THEORETICAL BACKGROUND IN
THE AGRI-FOOD INDUSTRY**

The impact of digital transformation on the agri-food industry is greatly influencing raw materials supply chain, production, processing, distribution, buying habits and so marketing (Weick 2001, Garai-Fodor – Popovics 2021, Keller – Huszka 2021). In addition, the digital transformation in food production fosters the creation of new types of machinery, such as 3D food printers (Charlebois & Juhasz 2018). Still, the technologies used to produce *space food*, which is the food of astronauts during the space missions, allow supplying healthy ready-to-eat food to busy people on *Planet Earth* (Varese & Cane 2017). Recently, the adoption of micro and nanotechnologies (Marette *et al.* 2009, Steenis & Fischer 2016) allowed, for example, the encapsulation of food active components (Roos *et al.* 2016). Consequently, firms could introduce many innovative new *functional foods* (Bigliardi & Galati 2013, Tollin & Erz 2017).

The happening of the digital transformation in the agri-food industry has divided customers into the open versus sceptics towards the adoption of new technologies. Older people are usually willing to pay a premium price for products treated with technologies that provide added health benefits (Leek *et al.* 2001). Conversely, millennials who care about sustainability issues are sceptical regarding the positive contribution of technologies to produce more sustainable food products and consider dangerous the technologies adopted to prolong food shelf life (Cavaliere & Ventura 2018, Steenis & Fischer 2016). Also, an increasing number of consumers fear the spread application of food additives (Szűcs *et al.* 2018).

However, a study on consumer preferences for familiar versus novel food products claims that age is not a determinant factor in consumption decisions with familiar products. At the same time, age plays a more decisive role in preference regarding novel

food products, particularly among young consumers (Barrenar *et al.* 2015). In the presence of irrational behaviours, customers may contrast new food technologies; this is a phenomenon known as *technophobia* (Gorgitano *et al.* 2017). To obstruct technophobia and change consumer attitudes toward food technologies adoption, firms need to associate food innovations with positive pictures, which have immediate benefits and prevent positive effects from extinction (Loebnitz & Grunert 2015). Briefly, to launch a successful new food product in the market, it is advocated to involve the customers in the food development process to improve consumers' acceptance (Busse & Siebert 2018).

So far, agri-food research has extensively explained how the food industry has employed technologies and what food products have been created by the intensive use of technologies (e.g. Leek *et al.* 2001, Marette *et al.* 2009, Steenis & Fischer 2016). These studies also profoundly investigate the role of the customer in the food industry, providing exciting insights regarding the technological centres, suppliers, retailers, and manufacturers too (e.g. Beckeman *et al.* 2013, Beckeman & Olsson 2011). Notwithstanding, just a few scholars studied the adoption of new digital technologies and focused on a pivotal phenomenon such as digital transformation in agri-food firms. Thus, previous research missed the opportunity to study the increasing availability of digital data generated by new technologies in food production and how the information provided by digital data processing can support product development (Schweitzer *et al.* 2019).

METHODOLOGY

This paper aims to provide a theoretical framework concerning how agri-food firms employ digital data for product development. Since agri-food firms' digital transformation is an empirically underexplored field of research, we adopt an exploratory multiple-case study design (Eisenhardt & Graebner 2007). We ground the theorising in the empirical data for an in-depth understanding of the research question.

Research sample and case selection

Our case-study research involves collecting and comparing data from 8 cases at agri-food firms in Italy. For example, a medium and a small firm process fruits and vegetables. A large firm produces olive oil, two medium-size companies produce dairy products, a large firm produces poultry product, and two small companies produce fresh and dry pasta. Among the agri-food firms, we selected cases from

food processing firms. This link in the food chain employs machinery – including digital technologies – to process raw materials and produce goods. So, we expected digital data for product development to be more transparent in this context compared with, e.g., the agriculture or retail settings.

We compared data from multiple cases and investigated whether an emergent construct was peculiar to a single case or regularly replicated in several cases. Thus, the multiple cases served as replication logic for our results, as contrary replication (observing cases where the availability of digital data did not lead to product development), or as elimination of alternative explanations (finding alternative explanations for product development) (Eisenhardt & Graebner 2007).

Data collection

We collected data from both primary and secondary sources: (a) semi-structured interviews with actors involved in the digital transformation strategy, digital data analysis, and product development process (e.g. CEOs, IT, R&D and Digital transformation specialists); (b) archival data (e.g. technological improvement and product development plans), company social media pages and websites. We adopted an interview protocol consisting of 12 questions and several bullet questions divided into three sections: 1) preliminary questions about the company, the interviewee and the context of the phenomenon; 2) questions related to the firm technologies that create digital data; 3) questions concerning how the firm exploit digital data to develop its products. The questions asked of the interviewees included, e.g., what kind of data does food processing machinery create? How does the firm save/store data about food processing? Which is the process the company follows for new product development? The eight interviews were recorded and transcribed within 24 hours. They lasted from 42 to 58 minutes. We complemented the interviews by collecting data from firms' social media, websites, and internal plans and reports (when made available) to triangulate data sources.

Data analysis

We conducted data analyses in four cumulative stages of coding, starting with the within-case analysis of each case, moving from the specific case context to the overall phenomenon (Saldaña 2015). We started with a preliminary within-case analysis of the 8 cases and their characteristics by reconstructing the summaries of different case studies. We segmented

and grouped data following a data-driven coding scheme during the first coding process. As a result, we identified a set of descriptive codes (Miles & Huberman 1994). Accordingly, the outcome of this coding stage was a list of codes as observed in the single-considered cases. In the second coding stage, we began with the abstraction process by either categorising new data under existing codes, grouping similar codes or creating a new code if it was analytically distinct. Consequently, we reanalysed the descriptive codes looking for interpretative codes (Miles & Huberman 1994) (Table 1).

Table 1. Summary of the descriptive and interpretative codes

Descriptive code	Interpretative code	Definition	Description	Illustrative quote
Incremental innovation	New product development	The creation of products with new or different characteristics that offer new or additional benefits to the customer.	Process in which data are involved to create new products or improve the current-produced ones.	“We have another benefit from data analysis. For example, we have shops where we directly sell our products. So, if we want to create some new product or test variations of the original product, we make tests in our stores and collect data from customers.” <i>Marketing Director, Case study 7.</i>
Radical innovation				
Internally created data	Data source	A data source is a location where data are stored.	Firms use various data sources for separate tasks or processes.	“When a product is particularly performing, it could push us to improve its characteristics or those of products that could interest the same consumer. In this case, we often base our analysis on the trend of internal data. While to find an indirect customer need, the best way is to try to interpret the sectoral market data. Market data are provided by the trade association and are national data.” <i>Technical director, Case study 3.</i>
Externally created data				

Source: edited by the authors

Then, we carried out the third stage of coding, which led the analysis to an additional level of abstraction. Starting from the previously identified interpretative codes, we looked for patterns (Miles & Huberman 1994). As a result, we identified two behaviours that explain how digital data are employed for product development: data receiver and data explorer.

The final stage of data analysis involved assessing the relationships among them. This final coding stage aims to connect the constructs and transform them from static and standalone behaviours into a dynamic and integrated theoretical framework (Figure 1).

DIGITAL DATA EXPLOITATION IN AGRI-FOOD NEW PRODUCT DEVELOPMENT PROCESS

Firms analyse data for several reasons. Our research focuses on the exploitation of digital data for product development in terms of additional benefits to the customer (incremental innovation) or the creation of new

products. Moreover, firms analyse data from sources such as raw materials, production processes, warehouses (data internally created) or data related to market trends, partnerships, competitors, and sales (externally created). We combined the types of product development processes with different data sources and found two behaviours connected to digital data exploitation: Data receiver and Data explorer (Table 2). These two behaviours can also be observed simultaneously in the same firm (Mixed behaviour).

The outcomes of our analysis are graphically represented in Figure 1, in which the digital data exploitation behaviours and their relationships are depicted.

Data receiver

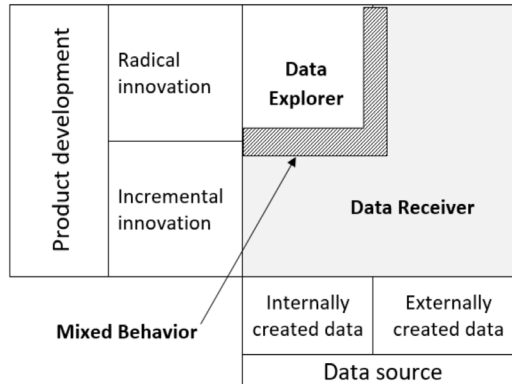
Data receivers have a passive attitude towards data analysis which is mainly done to produce standardised pieces of information to foster product development. The Data receiver is the most common behaviour among the firms in this study. According

Table 2. Summary of digital data exploitation behaviours

Phenomenon	Behaviour	Definition	Description	Illustrative quote
Digital data exploitation	Data receiver	A “Data receiver” waits for prearranged production information to make decisions.	Firms' passive behaviour that creates and collects data while the analysis produces prearranged information.	Then there are a bunch of analyses of product quality and productivity. We do not need to do additional analysis. From the data collected by the machinery, the information system generates information for us. Then, the man must interpret the information, but we already have all the analyses we need. <i>Managing director, Case study 1.</i>
	Data explorer	A “Data explorer” critically examines data to find new pieces of information.	Behaviour performed by firms that actively explore production data by deepening data analysis.	Machinery suppliers partially limit the company's autonomy to carry out independent analyses. As a result, we are forced to use and follow their models. However, we can carry out independent analyses thanks to the additional sensors that we insert in the machinery to produce an autonomous and parallel data collection. <i>Head of IT & Digital Transformation, Case study 8.</i>

Source: edited by the authors

Figure 1. Digital data exploitation matrix



Source: edited by the authors

to our analysis, Data receivers analyse data concerning internal aspects of the firm to improve current products by exploiting internally created data: *Each production is a test. The data are analysed to identify the strengths and weaknesses of the product. Over time, we improve our products, for example, by changing the flour mixture or inserting another type of raw material*, said the quality manager of case study 2. Data receivers also want to improve their current products (or create variations). They also analyse firms' external dynamics (e.g. sales or mark trends): *We track everything we sell. We usually invest in pro-*

ducts that sell the most to create variations. These variations are likely to be accepted by the market, explained the IT specialist of case study 4. Lastly, Data receivers are exploiting externally collected data to create new products. For instance, by analysing competitors' products, as the CEO of case study 6 put it: *We are followers regarding creating new products. We observe large companies that can make essential investments in research and development... then we analyse their products and try to adapt to what the most prominent companies do.*

Data Explorer

Such behaviour is adopted by firms that explore digital data by examining them with a critical eye and deepening data analysis to find novel pieces of information. Our analysis detected a few Data Explorers that query their database to create new products and understand whether they can do so. As the CEO of case study 5 up it: Production data are analysed to create new products. Therefore, we open new markets by analysing the production data to understand if the production plant can produce a product that presents new characteristics that make the product more attractive to the final customer. For example, it happened when we created the hamburger made of seitan.

Mixed behaviour

Among the Data explorers and Data receivers, some firms conduct both behaviours in distinct situations. Firms in this group behave as Data receivers when they exploit digital data to make simple or routinized decisions. To do so, Mixed behaviour firms use the standard information made available by the information system. On the other hand, when Mixed behaviour firms face new problems and have to make not-routinized decisions, they dig into the collected digital data to find information for supporting the decision-making process. Our analysis discloses that Mixed behaviour firms are the ones that better exploit their availability of digital data since they exploit internally and externally collected data to perform both incremental and radical innovation.

DISCUSSION

Building on prior research on digital transformation and digital technologies in the agri-food industry, our study contributes by providing the first insights about how agri-food firms exploit digital data for product development. Our research empirically demonstrates that digital data exploitation behaviours change according to the data sources employed by the firms when trying to develop their products.

Digital data exploitation behaviours and the lack of new product miners

Earlier research clearly identifies digital data as the key outcome of digital transformation (Dremel *et al.* 2017). Studies on technological innovation in food production shed light on how agri-food firms utilise

technologies (e.g. Beckeman *et al.* 2013, Grunert *et al.* 2008) and what new products have been developed due to the new technologies (e.g. Leek *et al.* 2001, Marette *et al.* 2009, Steenis & Fischer 2016). On the other end, they do not investigate the increasing availability of digital data in the agri-food sector and how the information gathered by digital data analysis can affect product development (Schweitzer *et al.* 2019). Our study extends previous research by identifying digital data behaviours and theorising how these behaviours change according to the data source and product development process. More specifically, previous research demonstrates that new technologies adoption has positive implications for product development. Our analysis suggests that firms mainly adopt a passive behaviour (Data receiver) when exploiting digital data for incremental and radical innovation. Data receivers feed their product development process with the information produced by the information system. However, the results also show that dynamic behaviour (Data Explorer) is needed to exploit internally created data (e.g., production data) to create new products. Despite the importance of exploiting digital data for new product development, Data Explorers are a minority. Instead, they display an active will to find a correlation between their available data and the possibility of creating new products (e.g., verifying whether the production plant can produce a new product or not). Finally, when firms can behave as Data Receivers and Data Explorers simultaneously (Mixed behaviour), they are also fully exploiting the potential of internal and external data to innovate their current products and create new ones.

Managerial implications

Concerning the exploitation of digital data for product development, our findings highlight that firms can be passive (Data receiver) or active (Data explorer) in analysing data internally or externally created. For example, practitioners may employ prearranged external and internal data analysis to make decisions about incremental innovation on current-produced products. The same happens when the firm makes routinized analysis on externally created data for radical innovation (e.g. when studying competitors' products). On the other hand, firms need to change their behaviour when analysing internally created data for radical innovation. In this case, practitioners who are active in mining and unconventionally analyse this sort of data would effectively find a correlation between, e.g., food processing data and the possibility of creating a new product. Finally, for

the practitioners interested in finding the best way to exploit digital data, our research unveils that firms behaving as Data Receivers and Explorers exploit internally and externally collected data to perform incremental and radical innovation. This mixed behaviour lets the firms better exploit their database since they can use them both for everyday decisions and critical ones.

Future research

The exploratory design of this research implies limitations that suggest avenues for further theoretical and empirical research. The restriction to food processing firms as the research's empirical setting provides a partial view of the digital transformation in the vast field of agri-food firms. Additionally, we based this study on a sample of 8 cases within a single geographical market (Italy). Future research is needed to extend our approach to other agri-food sectors (e.g. agriculture, retail), particularly in a multinational/multicultural context. A plurality of sectors and cultures may suggest different behaviours leading to digital data exploitation for product development.

Furthermore, our research considers the production firm's point of view. Hence, the analysis was based on data from just one actor. However, digital data exploitation also involves several players within the food industry, and each one may affect digital data exploitation. Therefore, future research could consider a multi-actor perspective to analyse the same phenomena by involving, e.g., software houses specialised in developing solutions for agri-food firms, digital data analysts, and machinery suppliers.

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