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Exploring the impact of blockchain on the performance of agri-food supply chains

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ABSTRACT

The implementation of the blockchain technology in the agri-food supply chains is in its introductory phase. Lead companies, often retailers, introduce this technology for specific objectives, such as assuring traceability or improving sales and reputation. At the same time, the technology could impact much more broadly the performances of food chains. Little is known about this impact as the evidence provided in the literature is scarce and mostly focused on specific indicators. This paper addresses this gap assessing the impact of the blockchain technology on food supply chains from an explorative perspective. An integrated conceptual framework is proposed which includes a broad set of performance dimensions discussed in the literature: efficiency, flexibility, responsiveness, food quality, and transparency of supply chains. These dimensions are assessed using a case study, consisting of three supply chains where a large European retailer has promoted the blockchain adoption. Data was collected through semi-structured interviews with key managers at different stages of the three supply chains and were systematically analysed through a thematic analysis. Results reveal that blockchain technology impacts positively on the profit and/or return on investment of supply chains, it leads to an increase of extrinsic food quality attributes and it fosters a better information management along the food chains due to an improved information accessibility, availability and sharing. The current analysis also suggests an improved management of behavioural uncertainty among the agents of the supply chains and an increase of firm's knowledge as well as supply chain management competencies. While the study remains of explorative nature, it offers a basis for the selection of theoretical approaches and the formulation of new hypotheses for future blockchain studies.

1. Introduction

In the last decades, a great number of food scandals have raised consumers' concerns related to the quality and safety characteristics of food products and the reliability of food labelled information (Aung & Chang, 2014; Kendall et al., 2019; Manning, 2016).

Governments have introduced normative measures to correct market inefficiencies and failures assuring the validity of labelled information of food products. Mandatory traceability introduced by Reg.178/2002 of the European Union (Commission of the European Communities, 2002) represents one of the most important instruments to assure and guarantee the information flows of food value chains in the European Union (Asioli et al., 2014). Besides mandatory traceability, several types of traceability systems are in place, that vary according to the amount of information traced, the stages of the value chain involved, the precision related to the trace-back of the products, and the possible needs of segregation (Stranieri et al., 2017; Varacca et al., 2014). The type of traceability adopted is highly influenced and driven by recent developments in information technology (DeGroote & Marx, 2013). The adoption of technological solutions, like Radio Frequency Identification technology, Electronic Identification and bar codes, smart packaging and devices, DNA tests, and biosensors, have enabled a more transparent and efficient management of traced products and better optimization of business processes, thanks to timely, accurate, accessible, available and high qualitative information (Trienekens at al., 2012; Swan, 2015). However, existing traceability systems do not assure a consistent information flow along the food chains (Badia-Melis et al., 2015).

Blockchain technology (BCT) is a digital technology which allows transaction and information flows without the need of intermediaries. More precisely BCT functionality relies on a 'digital transaction ledger,

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Abstract

The implementation of the blockchain technology in the agri-food supply chains is in its introductory phase. Lead companies, often retailers, introduce this technology for specific objectives, such as assuring traceability or improving sales and reputation. At the same time, the technology could impact much more broadly the performances of food chains. Little is known about this impact as the evidence provided in the literature is scarce and mostly focused on specific indicators. This paper addresses this gap assessing the impact of the blockchain technology on food supply chains from an explorative perspective. An integrated conceptual framework is proposed which includes a broad set of performance dimensions discussed in the literature: efficiency, flexibility, responsiveness, food quality, and transparency of supply chains. These dimensions are assessed using a case study, consisting of three supply chains where a large European retailer has promoted the blockchain adoption. Data was collected through semi-structured interviews with key managers at different stages of the three supply chains and were systematically analysed through a thematic analysis. Results reveal that blockchain technology impacts positively on the profit and/or return on investment of supply chains, it leads to an increase of extrinsic food quality attributes and it fosters a better information management along the food chains due to an improved information accessibility, availability and sharing. The current analysis also suggests an improved management of behavioural uncertainty among the agents of the supply chains and an increase of firm's knowledge as well as supply chain management competencies. While the study remains of explorative nature, it offers a basis for the selection of theoretical approaches and the formulation of new hypotheses for future blockchain studies.

Keywords: Blockchain, traceability, economic performances, food supply chains.

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1. Introduction

In the last decades, a great number of food scandals have raised consumers' concerns related to the quality and safety characteristics of food products and the reliability of food labelled information (Kendall et al., 2019; Manning, 2016; Aung and Chang, 2014).

Governments have introduced normative measures to correct market inefficiencies and failures assuring the validity of labelled information of food products. Mandatory traceability introduced by Reg.178/2002 of the European Union (EU) represents one of the most important instruments to assure and guarantee the information flows of food value chains in the EU (Asioli et al., 2014). Besides mandatory traceability, several types of traceability systems are in place, that vary according to the amount of information traced, the stages of the value chain involved, the precision related to the trace-back of the products, and the possible needs of segregation (Stranieri et al., 2017; Varacca et al., 2014). The type of traceability adopted is highly influenced and driven by recent developments in information technology (DeGroote and Marx, 2013). The adoption of technological solutions, like Radio Frequency Identification technology, Electronic Identification and bar codes, smart packaging and devices, DNA tests, and biosensors, have enabled a more transparent and efficient management of traced products and better optimization of business processes, thanks to timely, accurate, accessible, available and high qualitative information (Trienekens at al., 2012; Swan, 2015). However, existing traceability systems do not assure a consistent information flow along the food chains (Badia-Melis et al., 2015).

Blockchain technology (BCT) is a digital technology which allows transaction and information flows without the need of intermediaries. More precisely BCT functionality relies on a 'digital transaction ledger, maintained by a network of multiple computing machines that are not relying on a trusted third party. Individual transaction data files (blocks) are managed through specific software platforms that allow the data to be transmitted, processed, stored, and represented in human readable form' (Kamilaris et al., 2019, p. 240). Such technology enables a sustainable information management within food supply chains (Galvez et al., 2018). More precisely, BCT can differently contribute to solve challenges related to data reliability because the supply chain data infrastructure is available to all the actors of the supply chains. BCT provides more secure, transparent and accurate information sharing than other traceability systems (Iansiti and Lakhani, 2017). Moreover, this new way to manage information helps to reduce trust-related challenges among supply chain actors thanks to an enhanced information transparency and security (Feng et al., 2020) and it assures an augmented food integrity, i.e. the authenticity of food in food value chains with trustworthy information on food products characteristics (Galvez et al., 2018).

BCT started to express its potential in several sectors, such as banking, insurance, sharing economy, and the medical sector (Pazaitis et al., 2017). Some applications of BCT have been implemented also in the food sector, especially by large retailers, to assure traceability of food products (Creydt and Fischer, 2019). For example, Walmart has recently implemented BCT on Chinese pork and on Mexican mangoes and it revealed an improvement in the management of food safety issues along the chains (Kamath et al., 2018).

However, being the BCT a novel solution, much of the existing discussion on such technology has to do with the technical specificities related to the implementation of BCT (Galvez et al; 2018, Behnke et al; 2020, Prashar et al; 2020). In the agri-food-related literature some business studies have analysed the benefits of such new technology, even if convincing empirical experiences are still rare (Kamilaris et al., 2019). Such benefits deal with aspects related to supply chain management, food quality attributes and firms' economic outcomes. Feng (2020) stresses the importance of BCT to

reduce food waste, to accelerate logistic operations, and to improve information directly available to consumers. Tian (2016) argued about the possibility to relate product information to BCT in order to better manage food safety and quality issues within the diary supply chain. With regard to food quality aspects, Scuderi et al. (2018) stress the role of BCT in assuring the authenticity of PDO/PGI products in relation to the origin of raw material and the information about the production process. Moreover, Gertrude Chavez-Dreyfuss (2018) describe the use of BCT by Coca Cola in the sugarcane sector to avoid forced labour. With regard to BCT and firms' economic outcomes, Lucena (2018) stresses the importance of BCT in generating value added for export food products. Gunasekera and Valenzuela (2020) discuss upon the potential reduction of transaction costs deriving from the implementation of BCT. Kamilaris et al. (2019) argue that BCT can help food firms to mitigate food frauds and preserve firm reputation.

Despite the above described benefits, Ge et al. (2017) argue that most stakeholders are not ready for a paradigm shift towards blockchain-ready food chain, mainly because of a scarce awareness and knowledge about the technology and its economic implications. Also, Verhoeven et al. (2018) argued that the retailers have a low level of engagement with the BCT because they lack in the understanding of what are the true economic benefits from its adoption. Indeed, there is not still empirical evidence assessing the impact of BCT on the economic performance of food supply chains. Kamilaris et al., (2019) out of 49 identified projects worldwide in the agri-food sector highlight how only in 4 cases the BCT was fully integrated in normal operations, with the remaining examples being pilot studies used by firms as experimental tools or simply for visibility purposes.

This paper addresses this gap assessing the impact of the BCT on food supply chains performance from an explorative perspective. An integrated conceptual framework is proposed which includes a broad set of performance dimensions discussed in the supply chain literature: efficiency, flexibility, responsiveness, food quality, and transparency of supply chains. These dimensions are assessed using a case study, consisting of three private supply chains where a large European retailer has promoted the BCT adoption. Data was collected through semi-structured interviews with key managers at the different levels of the three supply chains and were systematically analysed through a thematic analysis (Nowell et al., 2017). A specific coding scheme has been developed for the purpose of the study. The explorative nature of the case study approach (Yin, 2003) also allows applying an inductive process for the identification of new relevant dimensions of performance. In fact, results will show that two other dimensions of supply chain performance should be considered when assessing the impact of BCT implementation, namely the vertical reorganization of supply chain transactions and the changes in resources and capabilities of the firms.

To the best of our knowledge, this paper is one of the first attempts to analyse the impact of BCT on the performance of food supply chains. Moreover, it contains also other elements of novelty. First, it offers an integrated economic assessment of supply chain performance by simultaneously using different economic performance dimensions. Differently, existing literature consider only specific performance indicators. Second, it reveals the presence of new performance measures related to the strategic dimension of the firm which are still missing in the existing BCT literature. In specific, the empirical analysis highlights the presence of a strategic dimension related to the adoption of BCT which affects positively supply chain vertical relationships and internal firms' resources and competences.

The paper is organized as follows. The conceptual framework is presented in section 2. Section 3 is about the explanation of the case study and the applied method. Results are described in section 4. Discussion is presented in section 5. Concluding remarks are in the last section of the paper.

2. Conceptual framework

Current debate on BCT addresses mainly the technical issues related to its implementation. It is recognized that BCT can be considered as a traceability system because it improves information management within food supply chains and it leads to an increase of food supply chain transparency (Biswas et al., 2017, Deloitte, 2017). Moreover, food-related literature on BCT argues that such technology has the potential to reduce administrative costs and improve supply chain performances, even if no study has already addressed this last point (Caro et al., 2018; Field, 2017). Thus, in the absence of specific frameworks for the evaluation of BCT, we constructed our conceptual framework referring to the literature concerning food traceability systems and supply chain performance.

The assessment of supply chain performance has gained much attention especially when a new traceability system is introduced along the food supply chain (Azfar et al., 2014; DeGroote and Marx, 2013). Existing studies have mostly focused the attention on the measures impacting economic performance of supply chains, i.e. efficiency, flexibility and responsiveness.

With regard to the efficiency of supply chains, several types of measures have been used to assess the profitability of resources used after the implementation of traceability, i.e. the production and distribution costs, the revenue and the return on investment (ROI) (Lai et al., 2002). Li et al. (2017) found out a potential enhancement in the efficiency and food quality of the investigated food supply chains. Saltini et al. (2012) report the presence of a positive impact of traceability systems on the turnover rate of material and stock quantity within cocoa supply chain. Moreover, Lao and Wang (2008) and Exposito et al. (2013) found a positive impact on ROI.

Concerning the flexibility of supply chains, the literature has identified some measures aimed at evaluating the effectiveness of supply chain actors after the introduction of traceability systems, i.e. their capacity of to react to unexpected changes in the economic environment and in consumer demand (Beamon, 1998). Such measures refer to customer satisfaction, volume flexibility, delivery flexibility, reduction in the number of backorders and lost sales. Yan et al. (2016) suggested potential positive gains in the traceability functionality and problem detection efficiency within the emu supply chain based on the Internet of Things. Also, Dabbene et al. (2014) and Badia-Melis et al. (2015) report a reduction of backorders costs associated to the adoption of traceability.

The measures to evaluate the responsiveness aim at evaluating the effectiveness in product management after the adoption of a traceability system (Persson and Olhager, 2002). Such measures include customer response time, fill rate, shipping errors, product lateness, and customer complaints. Parreño-Marchante et al. (2014) report an improvement of the managing of production flows within the aquaculture supply chain after the introduction of a traceability system based on web services. Moreover, Mai et al. (2010) conducted a case study in the seafood supply chain to analyse the impact of traceability highlighting a reduction of customer complaints after the implementation of such system. Also Asioli et al. (2014) stress how traceability allows an improved recall management within food supply chains.

In addition to the above measures, Aramyan et al. (2007) introduced food quality among the measures to evaluate the performance of food supply chains. According to Grunert (1997), quality is a category that captures the specificities of the agri-food products and it relates to the subjective perceptions of consumers towards a set of attributes (characteristics). Such attributes can be intrinsic and extrinsic (Olson & Jacoby,1972). Intrinsic attributes are related to the physical aspect of food (e.g. color, process characteristic, etc.). Extrinsic attributes are those characteristics which are associated to the

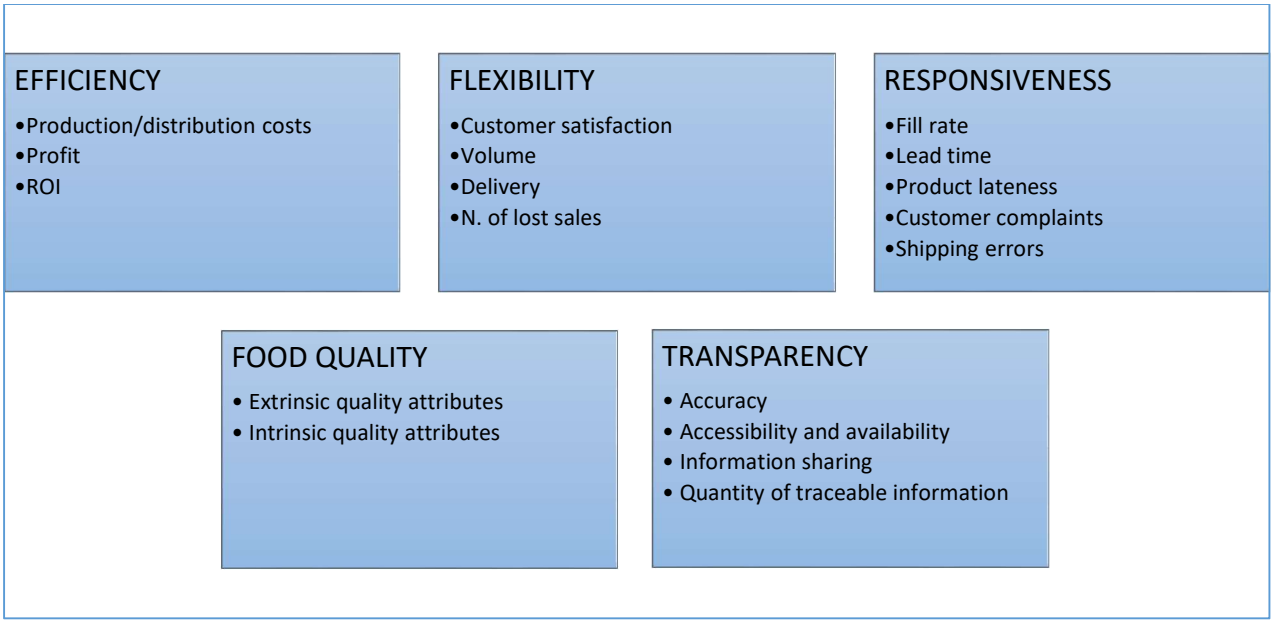
product but they are not part of it (e.g. brand, labels, packaging, price etc.). Aug and Chang (2014) stress how consumer consider traceability systems as important instruments to evaluate food safety and quality. Moreover, Chrysochou et al. (2009) reveal that consumer perceived benefits of traceability relate to the improved product-related information. The implementation of traceability systems impacts positively the consumers' willingness to pay more for products.

Also transparency can be considered an important measure to better manage vertical relationships within food supply chains as it lowers transaction costs (Stranieri et al., 2017). Besides financial and product flows, information flow is crucial to for the performance of food supply chain (Trienekens at al., 2012; Deimel, 2008). Literature stressed several dimensions to measure the degree of transparency within food supply chains, i.e the accuracy, the availability and accessibility of information and the degree of information sharing among supply chain agents. Information accuracy relates to the level of information precision (Forslund and Jonsson, 2009). Information availability deals with the degree to which food operators and/or consumers have access to information about product characteristics (Donnelly et al., 2013). Information quality refers to the accuracy and reliability of data exchanged (Chatfield et al., 2004). Information sharing refers to the degree to which the firm can collect data and store, retrieve and transfer documentation within the supply chain (Simatupang and Sridharan, 2001). According to Zelbst et al. (2010) information sharing refers to the ability of producing and sharing real-time information and data among manufacturers, suppliers and customers in a synchronized way, along the whole supply chain.

To the best of our knowledge, existing studies consider only a limited number of the above described measures to quantify the impact of traceability systems on the economic performance of food supply chains. The present paper fills this gap by using an integrated framework which considers simultaneously different measures to analyse the impact of BCT on the performance of food supply chains.

The figure 1 below shows a synthesis of the categories and measures used in the analysis to measure the impact of BCT on food supply chain performance.

Figure 1: Performance categories and measures from the conceptual framework

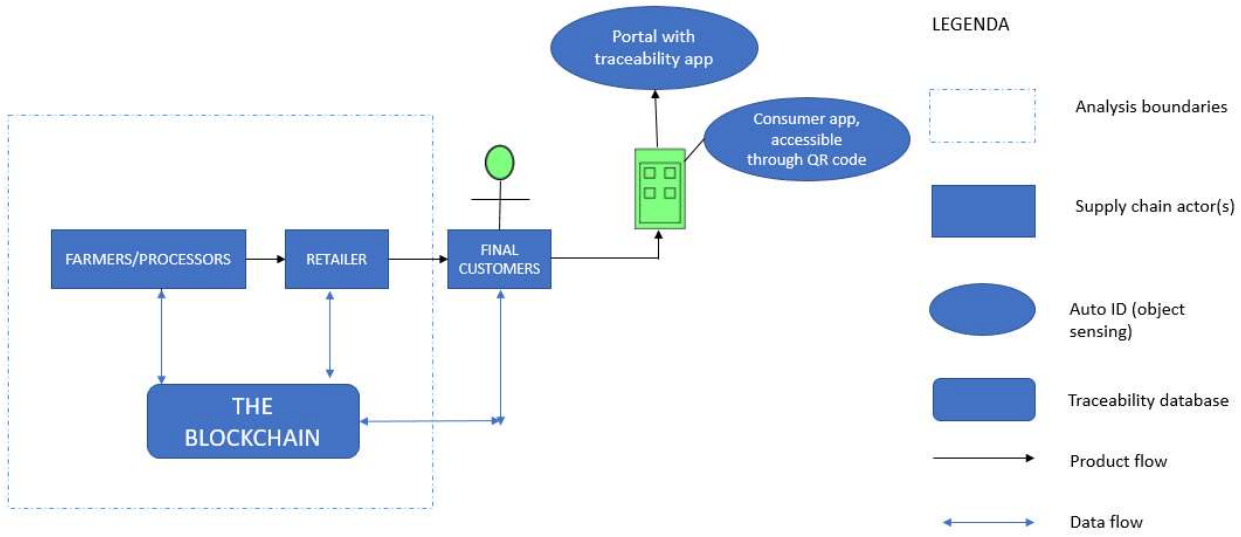


3. Methodology

3.1 Case study description

In the agri-food sector, there are few recent cases of supply chains implementing blockchains as technological solution, some through real implementation, others based on hypothetical applications and others as pilot projects (Kamilaris et al., 2019). The present study investigates the BCT project performed by a large European retailer (hereafter "the Retailer") which is a leading retailer in several European countries in terms of market share (top 5). BCT was implemented within one of its private label (PL) lines involving three different food supply chains. A general representation of the food supply chains investigated is reported in Figure 2.

Figure 2. Structure of the interviewed food supply chains



Source: own elaboration

The information flow in the BCT traceability platform is depicted by the dashed black line in Figure 2. The traceability of all products follows an event-oriented approach: traceability data is shared with partners in the whole supply chain. This represents a higher level of traceability compared to the compulsory "one step forward, one step back" approach. Such approach was undertaken within the Retailer's PL lines even before the BCT implementation. Every processor and the Retailer had their internal data management systems to retrieve and store traceability and control, planning, and operational data. Focusing on the BCT, with regard to all of the practices and operations performed from the fields to the packaging stations, the data are entered by the processors. The Retailer adds information as soon as products are received and allocated in the stores. The information flow in the BCT relates to: i) information on product origin, quantity, price, date and state and quality of goods at each stage of the supply chain (i.e. pesticides and/or antibiotics use, environmental monitoring parameters such as energy inputs, storage conditions among others); ii) information about the actors involved (cooperative members and employees handling the products) and data regarding the supplier's history and their handcraft; iii) additional technical information regarding the cadastral agricultural parcels upon contract specifications.

At the point of sale, final customers can scan the QR code on each package and retrieve information regarding the producers' history, the origin of the products and the production steps it went through along the chain. The strictly technical information flow is not available to customers. The Retailer decided to share to customers only data that holds a certain value from the consumer's perspective to avoid information overload.

The BCT platform implemented by the Retailer was applied to the following PL supply chains:1) the poultry meat supply chain, 2) the lemons supply chain, and 3) the oranges supply chain. These supply chains are among the first food supply chains that implemented the blockchain as technological solution. Moreover, the BCT is implemented along the entire chain ("from farm to fork").

The poultry meat supply chain was selected by the Retailer as it was considered the most appropriate for their first blockchain implementation. This poultry product was exclusively supplied by one processor that was highly integrated. This processor owned and/or controlled all of the steps of production, from the breeding activities (incubators) to the rearing, processing, and packaging of the final products. This high level of integration allowed a better control of the supply chain. In fact, the supplier was already managing a traceability data system covering all the necessary requirement in terms of pieces and flow of information. Moreover, the structure and characteristics of the poultry sector in European countries, which is concentrated in few processors with existing collaborations with retailers for quality labels, made it a likely candidate for the introduction of new supply chains procedures (Ghozzi et al., 2016; Passuello et al., 2015).

The BCT application in the lemons and oranges supply chains started a few months later, at the beginning of 2019. Beside the Retailer, the fresh lemons PL supply chain is managed by one supplier, whose activities and processes are again strongly integrated. The supplier is a cooperative of farmers that operates as a Producer Organization that manages all of the activities, including the farm production specifications of members of the cooperative, the harvesting, the packaging stage, and distribution to the Retailer. Similarly, the orange supplier is a cooperative of farmers organized in a Producer Organization integrating activities as described for the previous supplier, even if delivery to the Retailer is made through an external logistic firm.

3.2 Data collection

All of the involved actors in the described supply chains have been interviewed during the research in 2019. In total, interviews represented 3 processors and 1 retailer. A first face-to-face meeting was held with the Retailer. This company can be considered the focal firm, that is, the one promoting the implementation of the BCT. This meeting involved two managers, including a junior PL manager and the marketing manager, who were directly involved in the implementation of the BCT and were constantly supervising and monitoring its on-going operations. The meeting consisted of a general presentation of the BCT project, in which the two managers freely provided insights related to the background, features, structure, scope and accomplishment of the project. Additional insights were drawn thanks to few unstructured follow-up questions. The meeting allowed a clear identification of the actors involved and the managers to be interviewed within the supply chains. A summary of the background information retrieved during the first introductory meeting with the Retailer is reported in table A1 in the Appendix.

After the face-to-face meeting, four in-depth interviews were conducted by telephone and took place between one interviewer and one respondent. The choice of the interviewee has been driven by the identification of those managers having a direct role in the BCT implementation and supervision. In fact, the involved companies had different internal organizations and the people in charge of BCT from a managerial perspective had different formal positions. Three interviews were held with the processors' representatives: the marketing manager of the poultry supplier, the sales manager of the lemon supplier, and an external consultant of the orange supplier (who closely was taking care of the BCT project for the company). A conclusive interview was conducted with the Retailer (regarding each of the three supply chains under investigation), in order to complete the data collection.

As suggested by Kumar (2019), the interview structure and questions were first emailed in advance to the informants and at the beginning of the interview consent was asked for audio recording. Then, the interviewer introduced the research and the purpose of the interviews. It followed a main narration of the informant. This phase had a limited interaction between the informant and the interviewer. In a later phase the researcher asked specific questions and additional data. The interview closed with a wrap up and a brief final conversation with the interviewee.

The interview protocol was distinguished in two main phases (the questions included in each phase are detailed in table A2 in the Appendix):

In the first phase, the objective was to validate the proposed conceptual framework linking it to the specific supply chain and activity of the firm. Informants were asked open questions to gather this background information and later on they were provided with a list of performance categories and measures from the conceptual framework. To avoid misunderstandings each performance category and measure were briefly explained in the hand-out provided to the interviewee which is illustrated in table A3 in the Appendix. Considering the BCT and supply chain context in which they were operating, managers were asked to judge the general usefulness of these measures, their feasibility and measurability, and whether some indicators were missing. This allowed a fine tuning of the proposed model and provided possible indications for its extension.

In the second phase, the focus shifted in assessing the BCT impact on the identified measures of supply chain performance. Not all of the measures were assessed by each interviewee, as those that were considered of little relevance for the firm's supply chain activity were discarded. Each performance measure was assessed using open questions that allowed an in-depth understanding of the impact of the BCT implementation, including the reasons why a measure was impacted or not,

the type of impact, and the possible contribution of other drivers. The interview also investigated whether the measure was formally monitored within the firm and by which unit of measurement.

3.3 Data analysis

The data retrieved thanks to the interviews were systematically analysed through a thematic analysis based on Nowell et al., (2017). The work was organised in five phases.

Transcription: The interviews were recorded and later transcribed fully. The first organization of the data followed the original interview protocol: the text was structured following the interview questions. Data were organised in an Excel sheet with each cell included the text corresponding to the combination of interview question and interviewee.

Organization of the transcription: As a first step, contents of each interview were selected according to the relevance of the answers. For example, irrelevant technical examples, forced hypothesis and suppositions and out-of-context answers were taken out from the final text.

Data organization: Sentences were split in new cells according to their focus/reasoning. For example, in answering the question about the choice of measures for a performance category the interviewee might bring new evidence focusing on a different and not previously mentioned performance measure or might introduce a reasoning linking a performance measure to another one. The different focus/reasoning constituted a first general level of coding and a new column in the Excel file was created for it. Sentences having similar focus/reasoning were grouped in cohorts of cells (hereafter "cohorts"). Cohorts were organized according to the dyadic retailer-supplier relationship. This facilitated the comparison of contents. That is, for specific focus/reasoning, the answers of the processor and the Retailer were directly comparable. Note that, given the reorganization of sentences, cohorts were not necessarily following the initial set of questions of the interview protocol.

Coding: A specific coding procedure was applied for the purpose of the study that can be divided in two different approaches. The first approach relates to the performance measures that were provided by the proposed framework. As these measures could be picked by the interviewee from the questionnaire, the coding consisted in defining when a measure could be considered impacted positively, negatively, or unchanged. The second approach was more explorative as it followed an inductive process allowing the identification of new themes. Beside the pre-identified performance measures, new focus/reasoning were identified and the respective cohorts characterized with new codes. Two new performance categories, together with their dimensions and measures, were identified: supply chain governance and resources and capabilities. To qualify as a performance category, similar paths of reasoning had to come from more than one interviewee. The newly identified dimensions were categorized using available theoretical concepts, such as, for example, those from Transaction Cost Economics (Williamson, 1996) and Resource Based View (Barney, 1991). Table A.4 in the appendix describes the coding scheme.

Aggregation: the measures and the way BCT impacted them were first assessed at the individual firm level and then at the supply chain level. At the firm level, the impact on a measure was obtained as the number of times codes pertaining to this measure were retrieved from the interview. In this process the direction of the impact was also considered. At supply chain level, results of single firms were aggregated. An impact could be considered generalizable for the supply chain when all respondents offered for the same measure a consistent answer. Therefore, when a measure was considered relevant

only by a subset of interviewees or when the impacts were not reported as going in the same direction the result was not confirmed at supply chain level.

4. Results

The results of data analysis are summarized in Table 1, reporting the different themes and measures assessed at the individual firm level, and in Table 2 which aggregates results at supply chain level.

Concerning the impact of BCT on the economic efficiency of the firms, in the three supply chains each producer and the Retailer perceived no impact on production and distribution costs. Differently, an increase in profit can be generalised at supply chain level for the poultry and oranges supply chains that experienced a sharp increase in sales. The augmentation of ROI is confirmed only in the lemons supply chain, which highlighted a better management of production costs, i.e. a decrease in product loss and an improved warehouse management.

The impact of BCT on flexibility mainly relates to an increased customer satisfaction. The Retailer stated that "the project was initiated to assure a great level of transparency to the final customer and, in this regard, we observed a greater level of satisfaction compared to before". This greater satisfaction was perceived also by the lemon producer confirming this result at supply chain level. Differently, volume and delivery flexibility did not show significant differences according to the interviewee and the number of lost sales was not considered as a relevant variable. Moreover, BCT did not overcome other key flexibility problems, such as the uncertainty surrounding the produced volumes due weather conditions and other environmental factors in the fruit sector or, more generally, the difficulty in changing or substituting suppliers due to the stringent quality protocols applied in the PL supply chains.

Concerning responsiveness, no impact was revealed. The manager of the poultry supply chain reported an unchanged lead time with BCT implementation and the oranges processor did not reveal any change in product lateness. The other measures were not considered relevant for the supply chain. Transacting parties were already regulating these performance measures while stipulating contracts and were involved in steady relationships since long time.

The impact of BCT on the intrinsic and extrinsic food quality attributes was linked to an increase of product labelled information. All the supply chains analysed reported an improvement of extrinsic product quality attributes with the introduction of BCT. Such positive outcome was related to an augmented and dynamic product-related information on the QR code of the product label. The BCT allowed to augment the transparency along the supply chain and gave consumers the possibility to increase the understanding of the product quality. As the Retailer stated: "The BCT project is strongly connected to marketing. We want to say something more to our customers, increasing the transparency at supply chain level. The bigger opportunity the BCT gave us since the very beginning was to tell a story behind every good in a different and new way". Apart from this positive influence in the food quality extrinsic attributes, results do not suggest particular improvements on product intrinsic attributes.

With regard to supply chain transparency, none of the interviewee mentioned relevant positive or negative changes in the degree of accuracy of data they handled along the supply chain. On the other hand, interviewee mostly agreed that BCT provided an improved accessibility and availability of data as well as information sharing. Such information included production and process attributes of food and a more detailed characterization of the partners involved within the supply chains. This last concept can be summarized by the following quote from the oranges supplier: "The data coming from

the farming and harvesting stages are collected and sent to the BCT through a CSV file and they flow from the orange orchards till the final customers. We put the producers' face on the product label". Moreover, the supplier stressed that "the BCT allows the information and data to flow with less impediment along the supply chain, compared to the traditional situation".

In addition to the measures and themes confirmed and assessed by the interviewee, two additional themes originated from the content analysis and were interpreted and coded on the basis of the existing theoretical frameworks on firm strategic behaviour: "Supply chain governance" and "Resource and capabilities".

Concerning the supply chain governance theme, respondents highlighted several transaction-related measures impacting the performance of their supply chains due to the implementation of BCT. The Retailer acknowledged an increase of collaboration with the PL processors. The poultry supplier recognized an improvement of the management of vertical relationships. Within this context, the Retailer stated: "The novelty and the step forward of BCT lies in the fact that we are no longer the owners of information and data related to the product, but this property is now shared among partners. So there is a greater allocation of responsibilities and an increase of collaboration with our partners than before".

The increase of supply chain transparency reduced unfair practices and allowed a better management of opportunistic behaviour among economic agents. However, the limited knowledge associated to this new technology in the food sector brought to an increase of technology uncertainty within the chain. Such uncertainty led to an increase of costs associated to the time to learn how to manage new procedures. In fact, this uncertainty was mainly related to the possible errors in entering the data and in properly manipulating the information to be uploaded in the platform.

BCT also increased asset specificities. Transaction physical asset specificity originated from the costs for technological and operational adjustments for BCT implementation and the costs to adopt such technology, i.e. the cost of the technology investment and the cost of consultancy. The lemons and oranges suppliers also revealed an increase of transaction human asset specificities due to the costs of training and formation of personnel who had to learn how to enter and manage data in the new system. However, such augmented human asset specificity could be reduced in the long run because of the drop of skilled jobs (i.e. intermediaries) after the implementation of BCT (Kamilaris et al., 2019).

With regard to the theme of resource and capabilities, the poultry and oranges suppliers stressed an increased possibility to leverage resources thanks to BCT as it allowed developing experience and know-how. The oranges supplier was straightforward on this: "Blockchain is a challenge that we believe we have won. For us, this year has been more about testing ourselves, acquiring new knowledge and gaining experience". The introduction of BCT allowed an improvement of capabilities for almost all of the interviewee. New competences allowed to: 1) differentiate the BCT actors from their competitors and gain competitive advantage, 2) increase the ability of supply chains to adopt future innovative solutions, 3) augment the skills to discover and manage firm weaknesses, and 4) strengthen personnel awareness. Within this context, the lemon supplier stated that "BCT helped developing better and more efficient working practices". Moreover, the Retailer stressed how BCT helped its business to gain competitive advantage: "we adopted BCT because we want to be among the first not to miss this train. We are among the first to have studied the instrument in some way and this help us to gain advantage". Also it stated "We adopted BCT with an exploratory and educational spirit, being a new tool especially in the food and retail sector".

Most of the supply chains showed that BCT led to an increase of firm value due to the creation of new knowledge based on new practices focused on the integration of new ICT-supported solutions for the management of product and information flows within the supply chains. BCT also developed new competences related to the management of supply chains.

Table 1. The impact of blockchain on the performance of firms

Themes	Codes/Measures	Poultry supply chain		Lemons supply chain		Oranges supply chain	
		Producer	Retailer	Producer	Retailer	Producer	Retailer
Themes of the conceptual framework							
Efficiency							
	Production/Distribution costs	0	0	0	0	0	0
	Profit	+	+		+	+	+
	ROI (Return on investment)		+	+	+		+
Flexibility							
	Customer satisfaction	0	+	+	+	0	+
	Volume	0	0	0	0	0	0
	Delivery	0	0		0	0	+
	Number of lost sales					0	
Responsiveness							
	Fill rate	0		0			
	Lead time	0	0		0		0
	Product lateness		0		0	0	0
	Customer complaints			+			
	Shipping errors					0	
Food quality							
	Intrinsic quality attributes/product characteristics	0	++	0	++	+	++
	Intrinsic quality attributes/process characteristics			0			
	Extrinsic quality attributes/labelling	++	+++	+	+++	+	+++
Transparency							
	Accuracy	+					
	Accessibility and availability	+	+++	+	+++	+	+++
	Information sharing	+	+		+	+	+
	Quantity of traced information					+	
New themes							
Supply chain governance							
	Vertical coordination	+	+		+		+
	Behavioural uncertainty	-	-	-	-	-	-
	Technological uncertainty	+	+	+	+	+	+
	Physical asset specificity	++	+	+++	+	+++	+
	Human asset specificity			+		+	
Resources and capabilities							
	New knowledge creation	+	+		+	+	+
	Capabilities improvement	+	++	++	+		+

Note: 0: no impact; +: increased and code retrieved at least once from the interview; ++: increased and code retrieved at least twice from the interview; +++: increased and code retrieved at least three times from the interview; blank space: not mentioned by interviewee

Table 2. The impact of blockchain on supply chain performance

		Poultry supply chain	Lemons supply chain	Oranges supply chain
Efficiency				
	Production/Distribution costs	0	0	0
	Profit	+	/.	+
	ROI (Return on investment)	/.	+	/.
Flexibility				
	Customer satisfaction	<>	+	<>
	Volume	0	0	0
	Delivery	O	/.	<>
	Number of lost sales	n.m.	n.m.	/.
Responsiveness				
	Fill rate	/.	/.	n.m
	Lead time	0	/.	/.
	Product lateness	/.	/.	0
	Customer complaints	n.m.	/.	n.m.
	Shipping errors	n.m.	n.m.	/.
Food quality				
	Intrinsic quality attributes/product characteristics	<>	<>	+
	Intrinsic quality attributes/process characteristics	n.m.	/.	n.m
	Extrinsic quality attributes/labelling	+	+	+
Transparency				
	Accuracy	/.	n.m.	n.m.
	Accessibility and availability	+	+	+
	Information sharing	+	/.	+
	Quantity of traced information	n.m.	n.m.	/.
Supply chain governance				
	Vertical coordination	+	/.	/.
	Behavioural uncertainty	-	-	-
	Technological uncertainty	+	+	+
	Physical asset specificity	+	+	+
	Human asset specificity	n.m.	/.	/.
Resources and capabilities				
	New knowledge creation	+	/.	+
	Capabilities improvement	+	+	/.

Note: 0 no variation; + increase; - decrease; <> divergent opinions; /. not generalizable (not all respondents consider the measure relevant); n.m. not mentioned as relevant by all respondents.

5. Discussion

The results presented above offer new insights in relation to existing knowledge on food supply chain performance and traceability systems.

With regard to the assessment of supply chain efficiency our findings are in line with the results of Lao and Wang, (2008) and Exposito et al. (2013) who emphasize the positive impact of a traceability system on the performance of supply chains. More precisely, the results confirm that also BCT contributes positively to the income statement like other traceability systems, thanks to the increase of profits and to unchanged production costs.

Moreover, the analysis reveals that the adoption of BCT brings only to an increased level of customer satisfaction along the food supply chain, highlighting that BCT can be used as a useful tool to improve vertical relationships in terms of successful relationships and enhanced vertical collaborations. This results confirms only partially the findings of Yan et al. (2016) and Badia-Melis et al. (2015), who stress how IT solutions impacts positively on different dimensions of food firm flexibility. The unchanged variation of other flexibility indicators in our analysis could be due to the type of supply chains analysed, i.e. PL supply chains. In such kind of chains, a retailer centralizes negotiation, information and monitoring activities along the supply chain (Banterle and Stranieri, 2013). Thus, most of the operations within PL supply chains are already planned, managed and controlled by retailers. As the Retailer stated: “Planning is the key. We didn’t experience any change in the poultry supply chain, because we have a planning system that matches almost flawlessly supply and demand most of the times”.

The present results do not confirm a positive impact of BCT on the responsiveness of agri-food supply chains like the empirical studies of Parreño-Marchante et al. (2014), Mai et al. (2010) and Asioli et al. (2014) based on the analysis of different traceability systems. The absence of an impact of BCT on the responsiveness of food supply chains reveal that the management of product flows along the chains interviewed was already well optimized. This underlines how the implementation of BCT in the agri-food supply chain is not only based on the improvement of a mere economic transaction as it happens in other sectors like, for example, the financial sector.

The findings are also in accordance with existing literature which reveals an enhancement of food quality and safety after the implementation of traceability systems (Exposito et al., 2013; Yan t al., 2016; Biswas et al., 2017; Wang et al., 2017). However, the present analysis highlights an improvement of only extrinsic product quality attributes. No variation on the intrinsic product and process attributes is revealed. This might be explained by the fact that the actors of the private label supply chains considered have already agreed upon product quality protocols in order to be part of the chain organized and controlled by the retailer and they have followed and applied such rules before the implementation of blockchain.

The results on BCT confirm also the studies arguing a strong positive impact of traceability systems on the level of transparency (Lao and Wang, 2008; Donnelly et al., 2013; Tian, 2016, Yan et al., 2016, Biswas et al., 2017; Li et al., 2017, Wang et al., 2017). Moreover, the present findings stress that the increased transparency brought by BCT lie in the improved level of information accessibility, availability and information sharing. This is due to the fact that the supply chain interviewed had already traceability system before BCT and the introduction of this technology does not increase considerably the transparency of supply chains but it improves the sustainability and quality of information exchanged (Galvez et al., 2018).

The introduction of the new themes 'supply chain governance' and 'resource and capability' highlight that BCT is not only considered an instrument to enable transparent and trustworthy transactions within the food supply chains but also as a strategic tool that can have consequences on the reorganization of supply chains and on the resources and competences of food firms. More precisely, the augmented specific investments along the supply chains for the implementation of BCT lead to an increase of bilateral dependency among economic agents and to a higher level of coordination of vertical relationships. This can have advantages in terms of steady relationships and increased collaboration among supply chain agents. Moreover, the adoption of BCT develop competences useful to manage innovation along the chain and other competences which allow to gain competitive advantage from competitors. Also the new knowledge developed by the adoption of BCT can be considered a useful instrument to enable new practices within the food supply chains.

6. Conclusions

The present study offers a comprehensive assessment of the impact of BCT on the performances of three different agri-food supply chains. The findings reveal that the implementation of BCT provided economic benefits in terms of profits and/or ROI. Moreover, an increase of extrinsic quality attributes related to product labelled information was observed. Results also highlight a better information management along the agri-food supply chains thanks to an improved information accessibility, availability and sharing. Differently, the flexibility and responsiveness of operations within the agri-food supply chains do not seem impacted, apart from the level of customers' satisfaction that reveals a positive variation.

In addition to the above findings, new measures of supply chain performance emerge as relevant when assessing the impact of BCT: they deal with the vertical reorganization of supply chain transactions and the resources and capabilities of the firms. The introduction of a BCT can lead to a more efficient management of transactions. This is explained by a reduction of behavioural uncertainty and an improved collaboration among supply chain stakeholders, which help to manage the increased technological uncertainty and the augmented bilateral dependency among supply chain actors after the adoption of BCT. The introduction of such new technology improves also the know-how of firms because of the new knowledge and gained experience. Several competences are achieved, in terms of firm competitive advantage, innovativeness, and increased ability to recognize and manage weaknesses within firms.

The present findings open space for managerial recommendations. The results highlight that the implementation of BCT is not only a way to achieve supply chain transparency but it is a means to achieve a strengthening of vertical relationships among supply chain actors. The adoption of this new technology offers the opportunity to improve the quality of collaborations and to build trust-based relationships within food supply chains. Thus, this technology can be considered by the firms also as a tool to better manage their long term strategies related to supply chain governance. Moreover, the increased information sharing brought by BCT enable greater stakeholders' inclusion and can facilitate the reduction of information asymmetry between consumers and producers. Also, the adoption of BCT enables to exploit new business models based on new value creation and improved competences within the agri-food supply chains. At the same time results show that there are areas where the adoption of BCT does not improve performances, such as the management of product flows and the intrinsic quality attributes of products. The analysed case study suggests that performances on these dimensions are a sort of pre-requisite for retailers the select where to implement of BCT. Therefore, this technology should not be seen by potential suppliers as a tool to gain market access

into retailers' networks, as fundamental elements, such as process and quality standards and consolidated commercial relationships, appear as a fundamental basis at least in this introductory phase of the technology.

The above-mentioned findings present some limitations. These are typical of case study analysis and mostly pertain to the external validity of the results. Although a comprehensive set of performance measures was used and assessed in three different supply chains, the number of firms was limited and they were all dealing with the same focal firm (the Retailer) promoting the BCT adoption. The three supply chains were already highly coordinated and this should be considered when interpreting the results. Therefore, results should be carefully generalized to other supply chains or different BCT implementation contexts. At the same time, we believe that the case study design provides useful insights and it is probably the most appropriate research method in this introductory phase of the BCT in agri-food supply chains. In fact, when little is known about a phenomenon and its impact, explorative case studies allow an in-depth scrutiny of the forces in action. This study offers an assessment of alternative performance measures and introduces new themes that appeared relevant when assessing a BCT impact on a supply chain.

Results from exploratory studies offer a basis for the selection of theoretical approaches and the formulation of new hypotheses. With a solid base from qualitative work and an increased adoption of BCT in the agri-food supply chains, future studies could benefit from a bigger sample and formally test generalizable hypotheses deepening the understanding of the BCT impact on the performances of food supply chains. Moreover, future investigations could explore more in depth the long-term impact of BCT on supply chain governance. Studying the adoption of BCT on less vertical integrated supply chains would also offer further insights. In fact, the Retailer decided to start implementing the BCT on more integrated supply chains as it is probably the best entry point to start a new project. However, the challenges are ahead when food retailers will start introducing BCT in more complex and less integrated supply chains. It would be interesting in such a context to analyse performances of the different actors, particularly when dealing at the farm level with smallholders that are high in number and less prepared to manage new technologies. Also, the consumer side is relevant and was only indirectly considered in this study when talking about the BCT impact on Retailer's sales and customer satisfaction. Performance indicators could be identified also for consumers, including awareness, knowledge, and understanding of different food quality dimensions. An improvement on such measures could affect consumers' welfare as they could lead to more efficient choices and reduce the occurrence of market failures. Finally, an in-depth evaluation of the barriers related to the implementation of the BCT for food firms could be investigated in order to find out possible solutions to encourage the adoption of such innovation in the agri-food supply chains.

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Appendix

Table A1. Background information retrieved during the first introductory meeting with the Retailer

General information regarding the supply chain (SC) features
• Structure of the poultry/lemons and fresh oranges supply chains • Name and number of the actors and number of facilities along the supply chains • Processes performed at each facility • Activities performed along the chains • Reasons behind the choice of implementing the blockchain on the poultry supply chain as first • Reasons behind the choice of implementing the blockchain on the Retailer's products lines • Performance measurement system in place along the supply chain • Performance measures monitored along the supply chains • Management of the information and product flow along the chain and related criticalities, before the blockchain • Systems and technological solution in place along the supply chains before the blockchain
Blockchain project characteristics
• Date of initiation of the project and next steps • Reasons of adoption of the blockchain • Functionality of the blockchain platform • Management of the information and product flow along the chain and related criticalities, after the blockchain • Systems and technological solution in place along the supply chains after the blockchain implementation • Current limitations of the blockchain implementation? (Costs, interoperability, security concerns...) • Next challenges and opportunities for the blockchain, and for the Retailer

Table A2. Protocol used as basis for the interviews with supply chain actors

Phase 1	
Objectives	Organization and supply chain characteristics
To assess the relevance of the data obtained from the interview To understand the characteristics and activities of each producer along the supply chain	• Who are the actors, apart from you, of the Retailer's supply chain? • Who else besides you are directly involved in the blockchain project and shares information on the platform? • What are the activities your firm undertake in the Retailer's supply chain? • (Only to suppliers) Have you already heard about blockchain before the Retailer proposed it to you? • (Only to suppliers) What were the first thoughts about the blockchain project, when it was proposed by the Retailer?
Objective	Firm's selection of performance categories and measures
To select the supply chain performance categories and measures, relevant for each supply chain and supply chain's actor (producer(s) and retailer)	• Looking at the proposed performance categories and measures (table A3), can you judge its general usefulness for monitoring the performance of the chain? • Would you suggest different measures, considering your objectives along the chain, the feasibility and measurability of the suggested indicators? • Would you suggest additional measures for the purpose of assessing the performance of the supply chain after the blockchain implementation? • Focusing on the performance category "name of the performance category", what are the 2 measures that are the most relevant to assess the efficiency of your operations along the chain? *Note: the above question repeats for each performance category illustrated in Table A3 (efficiency, flexibility, responsiveness, food quality, transparency) and related measures.* • Do you monitor the selected measures for each activity you perform along the chain (considering there is integration)? • What are the systems and measurements (and unit of measurement) you use to monitor each relevant measure selected?
Phase 2	
Objective	Blockchain impacts assessment
To understand the blockchain impacts on the performance of each supply chain	• Looking at the two measures selected under the ***efficiency/ flexibility/responsiveness/food quality/transparency*** categories, did you experience any difference, before and after the blockchain implementation? 1. If yes, what kind? 2. If no, why? • Are these differences totally or partially due to the blockchain implementation? Please elaborate. • In which activity/step of the chain did you experience these changes (considering there is integration)? • In conclusion, did you experience any change and difference in the ***efficiency/ flexibility/responsiveness/food quality/transparency*** of your activities/operations along the chain?

Table A3. Hand-out distributed to interviewee describing the performance categories and related measures.

Performance categories	Measures	Description
1.Efficiency It generally indicates how well the resources are used (Lai et al., 2002).	Production/distribution costs	The combined costs of raw materials and labour in the production of goods/ combined distribution costs, including transport and management costs
	Transaction costs	Costs, other than monetary price, incurred in the exchange of goods or services (e.g. research costs, negotiation costs and application costs)
	Profit	The positive gain from an investment or business after deducting all expenses. Alternatively, the profitability can be considered as a function of (an increase in) sales.
	ROI (Return on Investments)	A measure of a company's profitability that accounts how effectively the company uses its capital to generate profit
2.Flexibility "It is the degree to which the supply chain can respond to a changing environment and extraordinary customer service requests" (Aramyan et al., 2007).	Customer satisfaction	The degree to which customers are satisfied with products or services
	Volume flexibility	The possibility to modify the output levels of the produced goods
	Delivery flexibility	The possibility to change planned delivery dates
	Lost sales	An order that is lost due to out of stock as the customer is not interested in allowing a backorder
3.Responsiveness It is about providing a product or service at the right time and place, with the shortest possible lead time.	Fill rate	Percentage of ordered units shipped in a given order
	Product lateness	The amount of time between the promised delivery date of the product and the actual delivery date of the product
	Lead time	Total time required to produce a particular object or service
	Customers complaints	Complaints registered by customers about products or services
	Shipping errors	Incorrect product shipments
4. Food quality It contains extrinsic and intrinsic quality attributes	Extrinsic quality attributes	Extrinsic attributes are those characteristics which are associated to the product but they are not part of it (e.g. brand, labels, packaging, price etc.)
	Intrinsic quality attributes	Intrinsic attributes are related to the physical aspect of food (e.g. appearance, sensory properties, process characteristic, food safety, shelf-life, etc.)
5. Transparency It is about having a timely, accurate, and shared access to understandable information concerning product and process characteristics	Accuracy	The level of information precision
	Accessibility and availability	The degree to which food operators and/or consumers have access to information about product and process characteristics
	Information sharing	The degree to which the firm can collect data and store, retrieve and transfer documentation within the supply chain and the ability to do it in real-time and in a synchronized way
	Quantity of traceable information	The different types of information that is traced in the traceability platform

Table A4. Description of the coding scheme divided by theme

Performance category	Measures	Codes	Codes' description
Efficiency	Production/ distribution costs	Unchanged production/distribution costs	Mentions of no changes in fixed and/or variable production/distribution costs
	Profit	Increased profit	Descriptions of how the blockchain has brought to positive changes in profit
	ROI	Positive ROI	Mentions of a positive return on investment (in the blockchain project's context)
Flexibility	Customer satisfaction	Unchanged customer satisfaction	Mentions of no changes in the level of customer satisfaction
		Increased customer satisfaction	Descriptions of any positive change in customer satisfaction
	Volume flexibility	Unchanged volume flexibility	Mentions of no changes in the level of volume flexibility
	Delivery flexibility	Unchanged delivery flexibility	Mentions of no changes in the level of delivery flexibility
	N. of lost sales	No additional lost sales	Mentions of no changes in the number of lost sales
Responsiveness	Fill rate	Unchanged fill rate	Mentions of no changes in the usual and planned fill rate
	Lead time	Unchanged lead time	Mentions of no changes in the usual and planned lead time
	Product lateness	Unchanged product lateness	Mentions of no changes in the lateness of the product
	Customer complaints	Decreased customer complaints	Mentions of a decrease in the number of customer complaints
	Shipping errors	Unchanged # of shipping errors	Mentions of no changes in the number of shipping errors
Food quality	Extrinsic quality attributes/labelling	New promotional activities: labelling	Descriptions of any novel labelling applied to products
	Intrinsic quality attributes/Process characteristics	Unchanged working conditions	Mentions of no changes in working conditions
	Intrinsic quality attributes/Product characteristics	Unchanged product quality characteristics	Mentions of no changes in product sensory properties and shelf life, safety and health and/or reliability and convenience.
Transparency	Accuracy	Increased accuracy of data	Mentions of increase of the accuracy of data and information retrieved, collected and/or shared
	Accessibility and availability	Increased # info available to supply chain actors	Mentions of any raise in the n. of information available to supply chain actors
		Increased # info available to final customers	Mentions of any raise in the n. of information available to final customers
		Increased level of availability and accessibility	Mentions of increase of the level of access and availability of data along the supply chain
	Information sharing	Increased info sharing and data flow efficiency	Descriptions of any positive change in the degree of information integration and sharing with supply chain partners
	Quantity of traced information	Increased # of traceable information	Mentions of any additional piece of information flowing on the traceability platform
Supply chain governance	Vertical coordination	Increased collaboration, vertical integration and interdependence	Descriptions of any change in the level of collaboration, integration with and dependency to supply chain actors
	Behavioural uncertainty	Discouraged opportunistic and fraudulent behaviour	Descriptions how the blockchain has influenced the probabilities and/or risks of having or experiencing opportunistic and/or fraudulent behaviour.
	Technological uncertainty	Technological risks	Descriptions of technological risks due to errors in exploiting properly the blockchain functionality
	Physical Asset specificity	Technological and operational initial adjustments	Mentions of initial operational and/or technological arrangements and set-up adjustments
		Increase of technological specific costs	Mentions of the new technological costs supply chain actors sustained.
	Human asset specificity	Increase of training, formation and consultancy costs among supply chain actors	Mentions of the new costs related to training, formation and/or consultancy activities supply chain actors sustained.
Resources and capabilities	Capabilities improvement	Adapting innovative solutions (increase innovativeness)	Mentions of how the blockchain helped in increase the level of innovativeness.
		Increase of discovering weaknesses	Descriptions of any spill over effect related to the increased ability of recognize internal weaknesses
		Differentiate from competitors and gain competitive advantage	Mentions of how the blockchain helped supply chain actors differentiate from competitors
	New knowledge creation	Developing experience and new know-how	Descriptions of how the blockchain impacted on the know-how and experience of supply chain actors