Using blockchain in fashion supply chains: evidence from a multiple case study

Pamela Danese
Department of Management and Engineering, University of Padova, Vicenza, Italy

Riccardo Mocellin (riccardo.mocellin.1@phd.unipd.it)
Department of Management and Engineering, University of Padova, Vicenza, Italy

Pietro Romano
Polytechnic Department of Engineering and Architecture, University of Udine, Italy

Abstract

Blockchain is receiving widespread attention in the fashion industry and an increasing number of pilot projects is being launched by organisations to test its potential. However, there is little clarity about the reasons justifying the adoption of different BC-based systems by companies and how choices in terms of design and use can allow addressing different issues. To fill this gap, our research empirically investigates four cases of Italian pioneers operating in this setting. Findings reveal that there is an interplay between BC-systems capabilities and design/use choices which seem to be influenced by the initial purpose of use.

Keywords: Blockchain, supply chain management

Introduction

In recent years, several scandals that occurred in the fashion industry (e.g. 2013 Rana Plaza disaster, 2018 Luis Vuitton counterfeited bags sold in the 5-star Oberoy Hotel) have increased the end-customers concerns about products sustainability and authenticity.

Companies are experiencing a growing demand for details about the products' history, from raw material sourcing up to retailers, which gives evidence of the organizational care of the environment, social responsibility as well as guarantees of authenticity.

Digital advancements offer new opportunities to enhance supply chain (SC) visibility, by tracing and monitoring the different processes involved in the whole product life cycle. Among the prominent technologies, blockchain (BC) is receiving particular attention from scholars and managers due to its potential to provide a trusted, symmetric and transparent product traceability (Treiblmaier, 2018).

It is already known that BC systems can be used by companies for a variety of purposes –such as support products sustainability (Saberi *et al.*, 2019; Kouhizadeh *et al.*, 2021), deter counterfeiting (Cole *et al.*, 2019), improve SC efficiency (Wang *et al.*, 2019)– and are available in different configurations (Tönnissen and Teuteberg, 2019; Danese et al., 2021). Nevertheless, there is the need to shed light on the reasons leading organisations to adopt diverse systems configurations (Köhler and Pizzol, 2020).

In the fashion industry, despite BC is showing rich promises, real implementations are still at an early stage and there is a need of empirical evidence in the literature showing how companies can properly configure BC systems to face one or more of the above-mentioned issues (Liu and Li, 2020).

Based on these gaps, the motivation behind this research is to address the following research question:

R.Q: How can a BC system be designed and used to address the different challenges that companies face in the fashion sector?

Therefore, going beyond the significant hype generated by BC technology, this study aims to examine how it can be effectively used by companies to address SC issues that nowadays affect the fashion industry.

Theoretical background

Blockchain in the fashion setting

Fashion is one of the largest industries in the world economy that each year employs more than 60 million people and produce more than 150 billion garments worldwide (Choi and Luo, 2019). It is characterised by highly fragmented processes accomplished in global supply networks having multiple intermediary steps between raw materials production and the finished product (de Brito *et al.*, 2008). This leads to information asymmetries and opaque SCs, hence to a lack of transparency about where and by whom products parts and materials are sourced, transformed and assembled. Information is generally held in paper and various digital formats by the entities along the SC, resulting in errors and delays and requiring costly and time-consuming data reconciliations (Cole *et al.*, 2019; Nandi *et al.*, 2020).

On the one hand, low transparency limits the knowledge of the environmental and social impact of produced garments, e.g. if production has required an intense use of energy, chemicals and natural resources or if the working environments were harmful or unfair. On the other hand, in many situations, it does not allow to determine if a product is authentic or not. In recent years, the issue of trademark infringement and counterfeits becomes more substantial as globalization and online-based trade developed.

For the abovementioned reasons, giving evidence of each garment's history is becoming of pivotal importance for allowing both companies and final customers to identify any sources of non-compliance that occurred along the SC that can undermine product quality, authenticity and sustainability.

BC technology, for its inherent characteristics (e.g. transaction immutability and transparency, decentralized architecture, etc.), has been advocated for ensuring a new level of visibility by bringing together all the entities in the SC enabling a secure, immutable and transparent information sharing (Liu and Li, 2020). This allows to create a unique and shared version of truth about product history –i.e. by providing evidence about how a product has been sourced, processed and distributed along the SC- and therefore overcome information asymmetry and data redundancies (Tijan *et al.*, 2019).

Although BC is still in its infancy and the current body of knowledge in the literature is not extensive, several recent initiatives have been started worldwide in the fashion industry in order to grasp its potential efficacy in addressing fashion SC challenges, such as product counterfeiting (Choi, 2019), environmental and social sustainability issues (Joy *et al.*, 2015).

BC systems configurations and use

Academic and managerial literature have already recognized the existence of two different groups of aspects characterizing the design configuration of BC-based systems in place within the SC context, specifically: 1) BC technology, i.e. the technical characteristics underlying BC, and 2) the technological tools used in combination with BC (Tönnissen and Teuteberg, 2019).

As for BC technology, BC systems can be differentiated based on several technical aspects, such as the type of permission model (public or private), consensus mechanism, properties of blocks, use of smart contracts or token, etc.

Also, BC systems differ for the technological mechanisms used to complement BC, such as near field communication (NFC) tags, quick response (QR) codes, internet of things (IoT), artificial intelligence, distributed file systems for off-chain storage, mobile applications. These tools are respectively used to couple physical goods with their digital representation saved on BC while addressing product physical tempering, perform data collection/exploitation as well as permit SC partners and final customers to easily interact with the solution (Galvez *et al.*, 2018; Saberi *et al.*, 2019).

Despite many papers focus on how BC technology should be configured at the technical level or how it can be complemented by other technologies, studies adopting a systemic perspective and examining the different choices that can be taken in terms of BC system design and use (e.g. the type and amount of data that is recorded on the BC, the traceable unit, the type and frequency of data entry) are lacking.

Even though the existence of a link between the different ways in which BC systems are designed and used by companies and their capabilities has been recognized in the literature (Danese et al., 2021), it has not extensively studied yet and thus needs further investigation (Schmidt and Wagner, 2019). Moreover, literature does not provide an organic view of the key decisional areas that have to be addressed to properly configure BC to face the abovementioned issues in the fashion industry.

Methodology

Given the exploratory nature of the topic, we opted for an inductive multiple case-study approach, that is suitable to understand the contemporary and complex phenomenon of BC adoption in fashion SCs (Eisenhardt and Graebner, 2007; Yin, 2017). This methodology increases results reliability and validity by offering access to in-depth data, replication of findings and cross-case analysis (Yin, 2017).

The selected sample for the empirical investigation includes 4 Italian-based SMEs, focal companies of fashion SCs that were pioneers in BC adoption.

Data was collected in the period between May 2020 and December 2020. We conducted a series of semi-structured interviews based on a research protocol which includes predefined questions, while keeping a high degree of flexibility and obtaining additional explanation and personal views from informal conversations. Due to the geographic distance and restrictions related to the Covid-19 problem, interviews were conducted via phone/Skype calls (Creswell, 2013). Each interview lasted on average from 60 to 90 minutes.

In order to have a good view of the phenomenon under investigation, interviews were conducted with multiple respondents with different functional roles within the companies (e.g. managers of different areas, such as supply chain, purchasing, logistics, production) who were well informed about both the company characteristics and the adopted BC system (Bowen, 2008). In addition, we interviewed the four technology providers that developed the examined solutions to better comprehend the technical aspects. Considering all the respondents of firms and technology providers, a total of 14 interviews were conducted. Both the companies and the technology provider provide us with useful information related to the SC actors that have not been interviewed in this phase.

All the interviews were carried out by two researchers, recorded and transcribed verbatim with the previous consent of the interviewees. Interviews transcripts were then reviewed by key informants to ensure the reliability of the data.

To mitigate researcher biases, primary sources were supplemented with multiple sources of secondary data, such as web resources, internal reports or other documentation provided by companies (Eisenhardt and Graebner, 2007). Moreover, unclear issues were clarified with key informants by using follow-up emails.

In parallel with data collection, we performed data coding and analysis, following Miles and Huberman (1994) recommendations. In the first step of the analysis, we examined each case study individually, i.e. carrying out a within-case analysis (Yin, 2017). To this end, a detailed report was built for each firm. In the second step, a cross-case analysis was performed to clarify the similarities and differences among the 4 cases as well as develop a set of propositions.

Description of the cases

Since the four investigated companies decided to stay anonymous, we will refer to them with fictitious names, namely company "A", "B", "C" and "D". In order to make information about product quality and sustainability transparent to everyone inside and outside the organization, they all launched pilot projects based on the adoption of public BCs which ensure the transparency and immutability of registered information. However, beyond this common aspect, each company configure and use the BC system differently.

Company A

Company A represents one of the historic brands of the Italian textile industry, pioneer in BC adoption, that manufactures and sells clothes of a low-price level all over the world. The company is an integrated manufacturer as it is responsible for the production of cotton, yarn, fabric and finished products that sell in large part in their outlets. This gives the company full control of its supply chain, from raw material to final products.

It decided to implement a traceability system based on the Ethereum BC in order to make final customers aware of the high quality and sustainability of goods belonging to one of its product lines and in turn improve their buying experience and brand loyalty.

General information related to the company, products characteristics (e.g. bill of materials) and production quality standards (e.g. details on SC phases such as cultivation, harvesting, dyeing, weaving processes, etc.) is stored on BC. Moreover, the company stores information showing its commitment to sustainability, both social (employment of a large number of workers for manual harvesting in cotton plantation and respect of their rights) and environmental (reduction of emissions from transport vehicles, low use of chemicals). This information has been collected and grouped at a precise time period and then manually stored on BC.

To allow final customers to check the quality and sustainability of the garments, the company decided to apply a Quick Response (QR) code to each product that is the same for the whole product line. Scanning the tag with a smartphone camera, it becomes possible to access product-related information that is stored on BC through a dedicated web page, as well as information about the company, etc. Customers are given the chance to register to the company website to access additional content, such as the possibility to view the products they bought in different colours.

Overall, the implementation entailed low costs for the company (less than 0,01€ per product) considering that no additional hardware or processes changes were required.

Company B

Company B is located in Italy and produces several kinds of garments for the low-price market, using only natural and non-toxic materials. Its decision to implement a system based on the Ethereum BC has been determined by its desire to make transparent and certified to final customers the information that proves the company's respect of the environment and workers welfare. In this regard, the company sees BC as a communication and marketing leverage that could represent an innovative value proposition in its business model by allowing to provide customers not only with a product but with a certification of its environmental and human impact which should strengthen the brand reputation and customer loyalty.

The organizational commitment to sustainability is demonstrated by several strategic choices. First, most of the clothes are produced using the organic and environmentally-friendly Tencel fibre, which is obtained from the processing of cellulose extracted from eucalyptus trees that are farmed without the use of pesticides, GMO or chemical fertilisers. Compared to other non-biodegradable materials, such as cotton, it also allows a significant reduction of water consumption and toxic substances such as insecticides or pesticides. Second, the fibre dyeing process is performed using only non-toxic and biodegradable dyes. Third, the materials used to produce all the clothing items are grown, processed and dyed in Europe, i.e. transport CO_2 emissions are minimized.

The company has obtained several environmental certifications that have been uploaded on BC, together with those owned by its suppliers, as guarantees of sustainability of four of its product lines. For these products, the company also provide other information with the aim to certify the product quality and good working conditions. All the data was grouped and uploaded on BC only once -without subsequent updates- and therefore the company provides a sort of photography of its situation in a precise point in time. BC guarantees its integrity and accessibility.

All the garments belonging to a product line come with the same QR code, whose application required a simple re-layout of the label. Customers can access the information saved on BC related to a product by scanning the item's QR code with their mobile device camera, which redirects to a specific web page. Through this page, customers are also invited to provide personal information to receive incentives and advantages, such as discount codes or other types of coupons.

The adoption of the system required a few weeks and limited investments (an amount lower than 0,01€/product). No internal staff was required to manage the solution.

Company C

Company C is a major Italian producer of elegant tailor-made shirts for famous clothing brands that are sold worldwide as high-end products. The main rationale which pushed the company to adopt this innovative solution was the need to tackle counterfeit products. Moreover, the implementation has been fostered by the organizational desire to strengthen the relationship with customers by enhancing their experience via personalised services and promoting the organizational responsibility towards environmental and social issues. It is based on the Ethereum public BC that allows associating each product with verified, public and easily verifiable information concerning its characteristics (sizes and type of fabric, collars, cuffs), changes in the physical locations and the engaged actors along the whole SC as well as production processes.

While information about the products historical background limits the risk of frauds and misconducts by SC actors (e.g. non-respect of pre-defined quality standards) and provide customers with a warranty of originality, quality and sustainability, detailed data about product features ensure the product conformity with specifications requested by the latter and incentivizes products re-ordering.

During the production phase, an NFC washable tag needs to be applied to the finished collar of each shirt. Thus, the labelling process has been modified.

On the client-side, final users can access the shirt-related data by using a specific mobile application and putting their smartphone/tablet near the label.

To obtain complete single-product traceability along the different phases (design, raw materials sourcing, production, transport, distribution), that were originally managed by non-automated channels (telephone, email, fax and other) or paper documentation, it was necessary to involve the different SC actors to perform manual data entry on BC at each step of the SC by using a user-friendly interface.

The solution also provides the company with information about the order history of each customer allowing for more focused marketing operations. As regards the monetary investment, the solution costs around 0,10€ per product.

Company D

Company D produces and sells luxury clothing to customers who are willing to pay a premium price, both for the Italian and foreign markets. It is located in Italy and is currently piloting a solution based on the Ethereum BC with the aim to protect its products from illegal replicas and create trust with final consumers by giving them visibility to certified claims about product characteristics, origin, quality, environmental sustainability and employee welfare.

This was possible by exploiting the BC capacity of keeping a secure record of the products' journey along the entire SC from raw materials up to finished garment as well as information that certifies their quality (e.g. details on the fabric, raw materials, chemicals used), authenticity and sustainability, such as certificates of raw material origin or conformity of product and processes with regulations and standards in force.

The project stimulated the digitalisation of the SC, which processes were strongly based on hard copy documentation.

Every garment is univocally labelled with a secure NFC tag that prevents the replicability problem. It creates a physical-to-digital link between good and its digital identity and allows customers to retrieve the related information saved on BC by using a mobile application that needs to be installed on their smartphones.

This additional level of detail entailed higher costs (around 0,10€/product) since it required the involvement of dedicated staff in the different key activities of the SC to support the process of data collection and uploading. Data is uploaded manually on BC by using a specific front-end graphical software interface that is installed on the devices already used by the companies.

By using the system, the company obtain a trusted and unified view of the events that occurred during the whole product journey along the SC that allows to quickly identify and keep track of any inappropriate and opportunistic behaviour of different parties, such as subtle variation of agreements, misconducts, non-respect of pre-defined quality standards, etc.

Discussion and preliminary findings

By adopting a systemic perspective (Köhler and Pizzol, 2020), a preliminary cross-case comparison shows the existence of two different clusters of BC systems configurations that differ in terms of design and use. The companies' strategic priority seems to impact the choice of which one to adopt. In fact, while the first category is preferred by companies whose interest is mainly related to marketing, hence to improve final customer experience and brand loyalty (A and B), the second is chosen by those also viewing counterfeiting mitigation as a strategic priority (C and D).

For both of the identified clusters, Table 1 summarizes the main differences in terms of system design and use, suggesting what configuration is more appropriate based on the company's needs.

From a preliminary analysis, our findings show that all the examined BC solutions have been used by fashion companies as marketing leverage to support product promotion, improve customer loyalty and brand reputation. On one side, this meant using BC to communicate organisational efforts towards environmental and social issues. This is consistent with recent literature (e.g. Adams *et al.*, 2018; Saberi *et al.*, 2019) who observed that BC contributes to sustainable SCM by generating reliable information on the products history and social and environmental conditions, which can be always accessible for auditing purposes. On the other side, the solutions were used to gather customer data for their profiling and for the purpose of encouraging their involvement (e.g. offering coupon codes and suggesting other colours to promote the product reorder).

Only Cluster 2 companies use BC systems for addressing the product counterfeiting issue. Cases C and D show that, as affirmed by Biswas *et al.* (2017), BC systems can be considered suitable tools to reassure the final customer that the product is protected from fraudulent practices since they ensure provenance by providing a real-time and end-to-end SC visibility as well as major security against product cloning. As shown in table 1, a BC system aimed at tackling the counterfeiting issue by monitoring the SC actors requires a precise set of choices in terms of use and design (e.g. secure NFC tag, single product traceability, high frequency of data update). This confirms previous studies on BC adoption for counterfeiting (Danese et al., 2021).

Going into the detail of the design choices, it is worth noting that all the investigated solutions refer to public BCs which have several advantages compared to private BCs. In fact, unlike the latter, they are entirely decentralised and provide the access to indelible, timestamped, transparent and trustworthy insights about the quality and sustainability of each garment (Viriyasitavat and Hoonsopon, 2019). Moreover, each information recorded on public BCs is digitally signed by the SC entity involved that is therefore responsible for any false declarations. However, there are several differences between Cluster 1 and Cluster 2 in how the systems are configured.

First, solutions differ in the amount of product-related information that is collected and saved on BC as well as on the traced object that, according to Golan *et al.* (2004), are the two factors determining the level of traceability provided by this type of systems.

In our cases, while for solutions of Cluster 1 information is uploaded one time and is limited to the nature of the entire product line (what it is) and to its quality features (how it is), solutions belonging to Cluster 2 also provides timely transparency that clearly illustrates the entire journey of each product, with indication on the different geographical locations (where it is) and SC actors involved (who owns it). These additional details enable the company and the customers to verify if a product has been subject to irresponsible behaviours along the SC. Unlike Cluster 1, for which information about product line nature and quality need to be uploaded only once, the additional level of detail of single-product traceability requires a near-real time frequency of data update, hence the writing of a higher number of BC transactions -to each of which is associated a specific fee- that is performed by dedicated employees in every step of the SC. The active involvement of the SC actors results in additional costs and time.

Another difference concerns the choice of smart labels that, in both cases, contain the link to the information presented to the consumer. QR codes, despite they are easily replicable, is preferred for solutions of Cluster 1 since they are well-recognized by customers as a simple and fast way to access web pages and their use does not require additional costs. Instead, the use of more secure NFC tags combined with a mobile application ensures greater resilience against product cloning at the expense of costs and ease of use. In fact, these tags have a higher price than QR codes and also required the development of a dedicated mobile application to be read as well as changes to the labelling process, since each tag needs to be programmed separately and then attached to the correct garment.

The cost difference between the two clusters of solutions -less than 0,01€/product vs 0,10€/product- is mainly determined by the following factors: 1) Type of adopted smart label, 2) Need to develop a dedicated mobile application, 3) Amount of transactions written on BC (which in turn depends on the traceable unit and type of saved data), 4) Amount of paper document that need to be digitized (which in turn depends on the type of saved data), 5) Involvement of dedicated staff for data collection/uploading.

It is worth saying that in all the cases the issue related to the trustworthiness of uploaded data -the so-called "oracle problem" (Caldarelli *et al.*, 2020)- remains. In fact, despite BC can secure the data saved in it, it cannot prevent the upload of incorrect information. This can undermine the worthiness of the projects.

From the above, the adoption of more costly solutions may be justified for companies selling higher-priced products (in our case C and D) for which counterfeiting generally represent an issue. Future research can assess organizations intention to adopt in case of larger implementations that entail major costs.

Table 1 – BC systems configurations

	CLUSTER 1 (Companies A, B)	**CLUSTER 2** (Companies C, D)
Aim	Marketing	Marketing + anti-counterfeiting
Permission model	Public	Public
Traceable unit	Product line	Single product
Product-related saved data	Nature (What it is) Quality features (How it is)	Nature (What it is) Quality features (How it is) Changes of physical location (Where it is) Engaged actors (Who owns it)
Number of data upload (BC transactions)	One	Multiple
Staff dedicated to data collection and storage	Non needed	Needed
Frequency of data update	Null	Near real-time
Smart label	QR code	NFC
User front-end interface	Web page	Mobile application
Use of data analytics	Customer profiling	SC actors monitoring
Costs	Low (<< 0,01 €/product)	High (≈ 0,10 €/product)

Conclusions

The purpose of this study was to investigate how BC can be designed and used to deal with the critical challenges faced today by the fashion sector. To fulfil this purpose, this research examined four different case studies of companies that already implemented BC in this setting by gathering data through interviews. Examining practical implementations allowed to contribute to existing literature, that is mostly conceptual, with empirically grounded findings.

The preliminary findings suggest that the company strategic priority determines the design and use of the implemented BC solutions and that the latter in turn determines its potential in overcoming the different challenges of the fashion industry. Based on this, the research suggests general guidelines to configure and use BC in the fashion industry to exploit its different potentials based on the desired initial aim.

In particular, this research identified two main different ways in which BC can be designed and used (Figure 1) respectively for responding to two different purposes, i.e. as marketing leverage to enhance customers' experience while increasing their loyalty and as an anti-counterfeiting tool that combine both marketing efforts with the ability to safeguard garments authenticity. Both types of configuration appear valuable, in virtue of the BC intrinsic characteristics, to promote environmental and social sustainable garments by improving SC transparency and therefore giving the possibility to verify the compliance with labour laws or the sustainability of production processes.

In the first case (Cluster 1), the technology enables an effective information disclosure about products physical attributes and the organizational commitment to environmental and ethical issues as well as facilitate final customers profiling and induce the products reorder. This solution is preferred by companies interested in promoting the value of their productions, hence improving brand reputation and customer involvement in order to earn a competitive edge in the market and desire an economically viable solution.

On the other hand (Cluster 2), BC solutions played a key role in allowing companies to cope with the menace of counterfeiting. Compared to the first cluster, this requires, for each garment, the application of a secure and unique NFC smart tag as well as the creation of a trusted and incorruptible audit trail as it moves along the SC. Moreover, dedicated staff within each company is needed to collect and storage near-real-time data. This provides full knowledge of the chain of custody, i.e. timely information about changes in physical locations as well as the organisations involved in the processing and manufacturing of clothing in the different stages of the SC. Each product is therefore provided with transparent information about its provenance asserting that SC actors have followed ethical and environmental standards as well as guarantees of its quality and authenticity.

The study findings suggest that the choice of more costly BC solutions that also protect companies from counterfeiting can be suitable for those cases with higher requirements in this regards. Further empirical research is needed to evaluate the feasibility of larger-scale BC-based projects involving more complex SCs with multiple stakeholders as well as expand the scope to consider BC application in other sectors.

References

Adams, R., Parry, G., Godsiff, P., & Ward, P. (2017), "The future of money and further applications of the blockchain", *Strategic Change*, Vol.26 No.5, pp.417-422.

Biswas, K., Muthukkumarasamy, V. and Tan, W.L. (2017), "Blockchain based wine supply chain traceability system", *Future Technologies Conference*, pp.56–62.

Bowen, G.A. (2008), "Naturalistic inquiry and the saturation concept: a research note", *Qualitative Research*, Vol.8 No.1, pp.137–152.

Caldarelli, G., Zardini, A., & Rossignoli, C. (2021), "Blockchain adoption in the fashion sustainable supply chain: Pragmatically addressing barriers", *Journal of Organizational Change Management*, Vol. ahead-of-print No. ahead of print.

Choi, T.-M. and Luo, S. (2019), "Data quality challenges for sustainable fashion supply chain operations in emerging markets: roles of blockchain, government sponsors and environment taxes", *Transportation Research Part E: Logistics and Transportation Review*, Vol.131, pp.139-152.

Cole, R., Stevenson, M. and Aitken, J. (2019), "Blockchain technology: implications for operations and supply chain management", *Supply Chain Management: An International Journal*, Vol.24 No.4, pp.469–483.

Creswell, J.W. (2013), *Qualitative inquiry and research design: Choosing among five approaches*, Sage Publications, Thousand Oaks, CA.

Danese, P., Mocellin, R., & Romano, P. (2021), "Designing blockchain systems to prevent counterfeiting in wine supply chains: a multiple-case study", *International Journal of Operations & Production Management*, Vol.41 No.13, pp. 1-33.

De Brito, M., Carbone, V., Blanquart, C. (2008), "Towards a sustainable fashion retail supply chain in Europe: organisation and performance.", *International Journal of Production Economics*, Vol.114 No.2, pp.534–553.

Eisenhardt, K. M. and Graebner, M. E. (2007), "Theory building from cases: Opportunities and challenges", *Academy of Management Journal*, Vol.50 No.1, pp.25–32.

Galvez, J.F., Mejuto, J.C. and Simal-Gandara, J. (2018), "Future challenges on the use of blockchain for food traceability analysis", *Trends in Analytical Chemistry*, Vol.107, pp.222–232.

Golan, E., Krissoff, B., Kuchler, F., Calvin, L., Nelson, K., & Price, G. (2004), "Traceability in the U.S. food supply: Economic theory and industrial studies." *Agricultural Economic Report No. 830.*

Joy, A., Sherry, J. F., Venkatesh, A., Wang, J., & Chan, R. (2015), "Fast Fashion, Sustainability, and the Ethical Appeal of Luxury Brands", *Fashion Theory*, Vol.16 No.3, pp.273–296.

Köhler, S., & Pizzol, M. (2020), "Technology assessment of blockchain-based technologies in the food supply chain", *Journal of cleaner production*, Vol.269, October.

Kouhizadeh, M., Saberi, S., & Sarkis, J. (2021), "Blockchain technology and the sustainable supply chain: Theoretically exploring adoption barriers", *International Journal of Production Economics*, Vol. 231, January.

Liu, Z., & Li, Z. (2020), "A blockchain-based framework of cross-border e-commerce supply chain", *International Journal of Information Management*, Vol.52, June.

Miles, M.B., and Huberman, A.M. (1994), *Qualitative data analysis: an expanded sourcebook*, Sage Publications, Thousand Oaks, CA.

Nandi, M. L., Nandi, S., Moya, H., & Kaynak, H. (2020). "Blockchain technology-enabled supply chain systems and supply chain performance: a resource-based view", *Supply Chain Management: An International Journal*, Vol.25 No.6.

Saberi, S., Kouhizadeh, M., Sarkis, J. and Shen, L. (2019), "Blockchain technology and its relationships to sustainable supply chain management", *International Journal of Production Research*, Vol.57 No.7, pp.2117–2135.

Schmidt, C.G. and Wagner, S.M. (2019), "Blockchain and supply chain relations: A transaction cost theory perspective", *Journal of Purchasing and Supply Management*, Vol.25 No.4, 100552.

Tijan, E., Aksentijević, S., Ivanić, K. and Jardas, M. (2019), "Blockchain technology implementation in logistics", *Sustainability*, Vol. 11 No. 4.

Tönnissen, Stefan, and Frank Teuteberg (2020), "Analysing the impact of blockchain-technology for operations and supply chain management: An explanatory model drawn from multiple case studies.", *International Journal of Information Management*, Vol.52, June.

Treiblmaier, H. (2018), "The impact of the blockchain on the supply chain: a theory-based research framework and a call for action", *Supply Chain Management: International Journal*, Vol. 23 No. 6, pp. 545-559.

Viriyasitavat, W. and Hoonsopon, D. (2019), "Blockchain characteristics and consensus in modern business processes", *Journal of Industrial Information Integration*, Vol.13 March, pp.32–39.

Wang, Y., Han, J. H. and Beynon-Davies, P. (2019) "Understanding blockchain technology for future supply chains: a systematic literature review and research agenda", *Supply Chain Management*, Vol. 24 No.1, pp.62–84.

Yin, R. k. (2017), "Case Study Research and Applications: Design and Methods", *Sage Publications*, Thousand Oaks, CA.