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BLOCKCHAIN TECHNOLOGY FOR SUPPLY CHAIN TRACEABILITY: THE CASE OF SMES OF THE MADE IN ITALY

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Abstract

Purpose. *This research aims at investigating why and how blockchain technology (BCT) is used for supply chain (SC) traceability in SMEs of the Made in Italy.*
Methodology. *Expert interviews with managerial and technical staff of Italian SMEs adopting BCT for SC traceability of Made in Italy products and tech companies providing it.*
Findings. *BCT is used to increase transparency in SC traceability and trust among stakeholders, however, not many firms and consumers know about this technology or how to use it, and there is a lack of clear regulations. Most SMEs of the Made in Italy use BCT in their SCs for B2C marketing purposes. Many of the blockchain solutions provided notarize on public 3rd generation blockchains the hashes of the off-chain documents in which the adopters state the traceability information about their products, which is accessible via the provider's App. This kind of solution brings some risks to data reliability.*
Practical implications. *Managerial implications are presented, helping firms understating if they need BCT for traceability and what solution they can adopt based on their objective.*
Originality of the study. *The study provides empirical evidence on a novel topic which has not been thoroughly addressed in the academic literature.*

1. Introduction

Supply chains (SCs) have become increasingly complex, stretching globally and involving many actors (Zhang *et al.*, 2020), and have been affected by severe disruptions, such as those brought by the Covid-19 pandemic (Pujawan and Bah, 2022). At the same time, consumers have become more demanding of the provenance of the products they purchase, increasing the pressure on retailers and distributors to provide products with transparent traceability information attached (Kittipanya-ngam and Tan, 2020). Access to traceability information by SC stakeholders (i.e., suppliers, producers, distributors, retailers, authorities, certifiers, and customers) is recognized as a mechanism to ensure product quality and safety (Manzini and Accorsi, 2013) and increase customers' trust (Gharehgozli *et al.*, 2017). Hence, traceability systems that enable transparency in complex SCs are needed.

Companies usually store traceability information about their products in their centralized databases, making such information inaccessible to SC stakeholders (Agrawal *et al.*, 2021) and modifiable or removable by malicious actors (Haq and Muselemu, 2018). Centralized data management causes low transparency, information asymmetry (Mao *et al.*, 2018), lack of trust among SC stakeholders (Chan *et al.*, 2019), and makes it difficult to detect counterfeit products (Abbas *et al.*, 2020), increasing the chances of frauds on product quality and identity (Dabbene *et al.*, 2014).

Blockchain technology (BCT) has been proposed as a tool for companies to store and share their products' traceability information transparently by making it visible to SC stakeholders and immutable (Mahyuni *et al.*, 2020; Saberi *et al.*, 2019).

However, BCT has not been implemented extensively in SCs and there is a lack of empirical data on its applications (Gonczol *et al.*, 2020; Rogerson and Parry, 2020)blockchain, the technology behind the cryptocurrency, has been gaining increasing scientific and industrial interest. Due to the technology's innate distributed and immutable features, the adoption of blockchains on supply chains is one of the most promising recent applications. In this survey, we review academic researches and implementations of distributed ledgers on supply chains. We present the current state of research on the subject and summarize the benefits and the challenges of the distributed organization and management of supply chains. Focusing on industrial practices and use cases, we discuss the technical characteristics and maturity of the various industrial projects. Our goal is to assess the applicability of blockchains in the supply chain domain and to provide a foundation for practitioners and researchers to direct their future projects towards improving the technology and its applications.”,”container-title”:”IEEE Access”,”DOI”:”10.1109/ACCESS.2020.2964880”,”ISSN”:”2169-3536”,”journalAbbreviation”:”IEEE Access”,”page”:”11856-11871”,”source”:”DOI.

org (Crossref and benchmarking between different blockchain solutions (Sund *et al.*, 2020). Thus, there is a need for more case studies of real implementations of BCT (Antonucci *et al.*, 2019).

The adoption of BCT in SCs is a particularly relevant case study in Italy, due to the importance of Made in Italy products in the Italian economy (EU Blockchain Observatory & Forum, 2020). Indeed, BCT could be used by companies of the Made in Italy for business-to-consumer (B2C) marketing (Violino *et al.*, 2020)Frantoio and Leccino and against counterfeiting of their products (Caldarelli *et al.*, 2020). Small and medium-sized enterprises (SMEs) of the Made in Italy could benefit the most from applying this innovative technology since they usually do not have the means to fight the counterfeiting of their products (OECD, 2018).

Given the lack of evidence on the use of BCT for SC traceability and its possible implications for SMEs of the Made in Italy, this research aims at gathering primary data by conducting interviews with managerial and technical staff of Italian SMEs adopting BCT for SC traceability of Made in Italy products and tech companies providing it, in order to answer two research questions:

RQ1: What issues of supply chain traceability of Made in Italy products can blockchain technology address?

RQ2: Which blockchain solutions for supply chain traceability can SMEs of the Made in Italy use, according to their objectives?

The results contribute to the literature on BCT for SC traceability and provide practical insights for companies and policymakers to make informed decisions.

The paper first presents the theoretical framework on BCT for SC traceability. Then, the methodology is provided, followed by the findings. The results are discussed. Finally, the conclusions summarize the findings, propose managerial implications, and provide suggestions for future research.

2. Literature review

2.1 Transparency in supply chain traceability

SC traceability refers to access to information about a product (Olsen and Borit, 2013), like weight and temperature, energy and resource consumption, batch quantity and size, production, transformation, and distribution (Casino *et al.*, 2020). Transparency in a SC is the extent to which the SC's stakeholders have access to the information about a product (Hofstede *et al.*, 2004). Companies can make the traceability information about their products visible to SC stakeholders for several purposes: assure them of the safety and quality of the products (Sun and Wang, 2019); attest product provenance and identity against frauds and counterfeiting (Dabbene *et al.*, 2014); foster trust among SC partners (Casino *et al.*, 2020; Kittipanyangam and Tan, 2020); increase customers' brand loyalty and trust by giving them the possibility to check the quality and safety of the food they buy (Yu *et al.*, 2018). Contrarily, when companies do not share their SC traceability information, they create low transparency, information asymmetry (Mao *et al.*, 2018), and a lack of trust in their relationship with all SC stakeholders (Chan *et al.*, 2019). This can damage both products' buyers and sellers. As Akerlof (1970) explained, the lack of transparency about products causes information asymmetry, meaning that buyers cannot assess the actual quality of products which is known by the sellers. This creates mistrust and leads buyers to prefer buying products of certain low quality rather than uncertain high quality. The consequence is that buyers end up having lower-quality products overall, while sellers of high-quality products do not sell as much as they could if the information asymmetry had been reduced by product transparency, which is defined as the disclosure of traceability information concerning a product (Ospital *et al.*, 2022). Moreover, when consumers perceive a high risk due to information asymmetry, they can choose not to buy a product altogether (Zhou *et al.*, 2018). Consequently, ensuring transparency in SCs is beneficial both to consumers and companies.

2.2 Blockchain technology

BCT is a kind of distributed ledger technology (DLT) where a ledger containing transactions between peers is structured in blocks that are concatenated one to the other, forming an unbreakable chain of blocks (Chowdhury et al., 2019). As Nakamoto (2008) explained, a blockchain enables transactions to have the following characteristics: peer-to-peer, without intermediaries; digitally signed by the issuer and the receiver; timestamped, proving their existence at a certain point in time; can be appended only, without the possibility to change or remove them, making the ledger immutable; can contain text strings, making BCT useful to share textual information among peers; visible to all stakeholders. Immutability and visibility combined enable transparency, thus removing the need for intermediaries or trusted third parties to conduct and validate the transactions. Since any kind of data can be written inside the transactions, blockchains are a valid alternative to centralised databases to ensure data transparency and security (Bianchini and Kwon, 2020). Indeed, the centralised databases usually employed by firms are siloed, i.e., not visible to stakeholders interested in accessing the data they contain (Chowdhury et al. 2019). Also,blockchains are more secure than centralised databases because the ledger containing the transactions is copied in all the nodes of the blockchain network, thus eliminating the problem of the single point of failure caused by the single node's malfunctioning or hacking (Viriyasitavat and Hoonsopon, 2019). However, this technical feature also requires that new information is distributed to all the nodes of the network before any other additional information can be written in the database, making blockchains not as scalable as centralised databases (Gobel and Krzesinski, 2017), meaning that blockchains are generally unable to store huge amounts of data in a short time (The European Union Blockchain Observatory & Forum, 2019) unless the number of nodes is decreased, in which case the blockchain's decentralisation and security would be hindered (Del Monte et al., 2020).

Despite its technical limitations, blockchains still allow more data transparency than siloed centralised databases and are preferable to them when multiple parties wanting to share data between them do not trust each other and cannot (or do not want to) find a trusted third party to ensure the validity and immutability of such data (Chowdhury et al., 2018). The trust deficit is the most important requirement for choosing to use blockchains rather than centralized databases. As theorized by Sternberg et al. (2020), if trust between parties is already present, then the adoption of BCT would not create more trust and is ultimately unnecessary.

2.3 Blockchain for supply chain traceability

BCT enables transparency by making the products' traceability information immutable and visible to SC stakeholders (Mahyuni et al., 2020). Companies can store on a blockchain their products' traceability information stating the provenance of raw materials, components, or ingredients (Westerkamp et al., 2020), and proving their products' originality (Islam and Kundu, 2019). Once the traceability information is uploaded to a blockchain, a tag (e.g., RFID, NFC, QR code) is applied to the product and can be scanned by SC stakeholders to access the blockchain and audit the product's traceability information (Tan and Ngan, 2020; Violino et al., 2020).

Transparency in SCs is one of the most important applications of BCT for companies since it brings them many benefits (Alawi et al., 2022).

First, it can increase the accountability of all SC partners. Since the traceability data on a blockchain is immutable and visible, companies are discouraged from any misconduct (e.g., sharing false or inaccurate data) because of fear of reputational damage (Longo et al., 2019).

Second, the fact that the information in a blockchain is transparent enables trust between SC stakeholders (Wang et al., 2019). Nevertheless, while BCT can make the information uploaded to a blockchain tamper-proof

(Mirabelli and Solina, 2020), it cannot ensure that the information itself is correct, so it does not eliminate the risk of fraudulent behaviour (Violino et al., 2020). Hence, SC partners cannot fully trust that the traceability data uploaded to a blockchain by other SC partners are correct (Violino et al., 2020). Data could be incorrect due to voluntary tampering or human error. The solution proposed is to use the Internet of Things (IoT) to automate the processes of collecting and uploading traceability information to a blockchain, thus removing human intervention (Iftekhar et al., 2020). For example, Cocco et al. (2021) developed a SC traceability system for an agrifood SME combining BCT and the IoT to guarantee a reliable, transparent, and auditable product traceability.

Third, BCT in SCs can facilitate origin tracking and help identify counterfeit products (Hosseini Bamakan et al., 2021). Current anti-counterfeiting systems are inadequate because they rely on centralised databases to store the products' traceability information, which SC stakeholders cannot access to verify a product's originality; also, these databases are not secure and the data they contain can be changed to commit frauds in SCs (Abbas et al., 2020). Instead, with BCT-enabled SC traceability, the consumers can scan a tag on a product to recover immutable proof of its originality (Haq and Muselemu, 2018). In this way, consumers are involved in anti-counterfeiting (Ma et al., 2020), helping companies reduce their losses due to counterfeiting (Abbas et al., 2020) and build customers' trust and brand loyalty (Dujak and Sajter, 2019). This is especially relevant for SMEs because they usually do not have sufficient resources and capacities to monitor the threat of counterfeiting or to develop effective countermeasures against it (OECD, 2018).

Fourth, companies implementing BCT-enabled SC traceability allow consumers to get the information to make informed decisions (Bumblauskas et al., 2020). This could lead to an increase in revenues, both from an increase in sales by customers who value product transparency (Kittipanya-ngam and Tan, 2020) and from persuading them to pay a higher price compared to similar products that are not traced with BCT (Guido et al., 2020; Violino et al., 2019). These benefits could be higher for products for which consumers value provenance more (Rogerson and Parry, 2020).

Fifth, product transparency enabled by BCT can be used for marketing to consumers who value transparency in their purchasing process (Zhou et al., 2018). When consumers scan a tag, they access a webpage containing the product's traceability information, allowing companies to use that webpage to do storytelling about their products (Violino et al., 2020). Galati et al. (2021) and Compagnucci et al. (2022) found that Italian SMEs use BCT for agrifood SC traceability as a B2C marketing tool to present themselves as reliable and trustworthy to consumers, showcase their products as high-quality and safe, and have a more direct relationship with costumers.

Other benefits come from digital tools enabled by BCT: smart contracts and non-fungible tokens.

A smart contract is a self-executing program that digitally verifies and carries out traceable and irreversible agreements among peers when certain conditions specified in the contract are met, without the intervention of a trusted third party to execute the clauses of the contract; smart contracts run on a blockchain, making their code immutable and auditable (Zheng et al., 2020). Smart contracts can be applied to SC traceability to track products and automatically execute conditions (e.g., payments from the producer to its suppliers) when materials or products reach certain steps in a SC (Prause, 2019).

BCT also allows using non-fungible tokens (NFTs) to tokenize assets. Westerkamp et al. (2020) describe an NFT as a non-reproducible cryptographic token that stays on a blockchain and acts as a digital representation of a material or immaterial asset, constituting proof of authenticity and ownership; information about the changes of ownership of the asset and the money transactions involved is written in the NFT when these occur. NFTs can be used in SCs to tokenize and track products, their change of ownership and related payments (Chiacchio et al., 2022).

Despite the benefits of using BCT for SC traceability, some challenges could limit its adoption. Finding solutions to these challenges is crucial since the benefits of using BCT in SCs depend on the adoption of BCT by a critical mass of SC partners (i.e., suppliers, transporters, producers, distributors, retailers, and others) (Sternberg et al., 2020) and cannot be achieved if some of them do not share their traceability data since this would create gaps in traceability (Laforet and Bilek, 2021).

Some challenges relate to the lack of knowledge and regulations and some others to the technical features of BCT itself.

A lack of digital knowledge inside companies could limit their capacity to adopt BCT for SC traceability (Garrard and Fielke, 2020; Sternberg et al., 2020). This could be a problem especially for Italian SMEs that have low internal knowledge of digital tools (Bianchini and Kwon, 2020; Compagnucci et al., 2022). Bumblauskas et al. (2020) noted that BCT can benefit SCs only if traceability is well-practised by each SC partner, which depends also on the degree of digitalisation of the tracking process; although, while some companies are highly digitalized in the collection and storage of traceability data, many still use paper records (Garrard and Fielke, 2020). Moreover, companies that are already digitalized need to integrate BCT with their internal management software, such as Enterprise Resource Planning (ERP) (Tan and Ngan, 2020), and could encounter problems doing so (Al-Jaroodi and Mohamed, 2019). Additionally, companies may not be willing to adopt BCT in their SCs due to uncertainties caused by the lack of clear legal frameworks (Iftekhar et al., 2020), for example regarding data standardisation (Aung and Chang, 2014).

Other limitations to the adoption of BCT could come from two technical features of BCT. The first limit comes from the blockchains' low scalability, which can prevent companies from writing big quantities of data in a blockchain in a short time (Wang et al., 2019; Westerkamp et al., 2020). The second limit comes from the fact that the visibility of traceability data to the public, which is a feature of BCT, may not always be desirable for companies that value data confidentiality (Behnke and Janssen, 2020).

To overcome the negative effects of the two features of low scalability and lack of data confidentiality, "off-chain storage" can be used instead of "on-chain storage" to store SC traceability data. Hepp et al. (2018) explain that due to the low scalability of blockchains, storing a heavy file like a document, picture, or video in a blockchain with on-chain storage is too expensive and time-consuming. Instead, with off-chain storage, the file is first stored in a private database, while the file's hash is stored in the blockchain for reference. Since all hashes have the same light weight regardless of the size of the files they are derived from, uploading hashes on a blockchain instead of the actual files greatly increases scalability. A stakeholder having access to both the original file on the private database and its immutable hash on the blockchain can use the hash to verify that the file's content has not been modified. Additionally, hashes enable data confidentiality: they point to the file stored off-chain, but say nothing about the actual content of the file, which can be kept private in the off-chain database and made accessible to authorised users (Hepp et al., 2018; Shahid et al., 2020). However, a fundamental problem with off-chain storage is the risk of data loss. If a company stores a file off-chain in its private database and shares on-chain the hash pointing to it, then a malfunction of the database would make the content impossible to retrieve (Hepp et al., 2018). To enhance data integrity and retrievability, some researchers proposed using decentralized peer-to-peer databases for off-chain storage (Shahid et al., 2020), such as IPFS (Inter Planetary File System) (Salah et al., 2019).

The two challenges of low scalability and lack of data confidentiality have also led to the development of permissioned blockchains as a possible solution to both issues. Blockchains can be permissionless or permissioned, depending on their ownership and writing and reading rights (Song et al., 2019): permissionless blockchains are not owned by anybody and are public, meaning that everyone can write and read data on them (e.g., Bitcoin and Ethereum). Permissioned blockchains are private if they are owned by one actor or consortium if ownership is shared among multiple parties (Xu et al., 2017). Permissioned blockchains are more scalable (Dib et al., 2018) and preserve data confidentiality by allowing the owners to give access to sensitive business information only to certain actors (Bumblauskas et al., 2020; Chan et al., 2019; Mao et al., 2018). However, higher scalability in blockchains is usually achieved at the cost of lower decentralisation and security (Del Monte et al., 2020): permissionless public blockchains are the most distributed and secure, but the least scalable; private and consortium blockchains are more scalable but sacrifice decentralisation and security (Chowdhury et al., 2019; Dib et al., 2018).

A possible way to ensure scalability, decentralisation, and security, while ensuring also data confidentiality, could be using hybrid blockchains, where data is written on one blockchain and then passed to one or multiple other blockchains. For example, Wu et al. (2017) proposed a hybrid blockchain architecture where permissioned blockchains are used for sharing private business information among partners in a SC and information of public interest is then uploaded from these blockchains to a permissionless blockchain. The use of multiple interconnected blockchains is ideal for simplicity, adaptability, and extensibility, but interoperability between them must be ensured (Sparer et al., 2020), which remains a challenge (Laforet and Bilek, 2021).

3. Methodology

Given the lack of empirical data on the use of BCT for SC traceability, this research aims at gathering primary data from SMEs using it and providers of BCT solutions. The objective is to understand what issues of SC traceability of Made in Italy products can blockchain technology address (RQ1) and which blockchain solutions for supply chain traceability can SMEs of the Made in Italy use, according to their objectives (RQ2).

The expert interview methodology is used as qualitative empirical research conducted to explore a specific field (Döringer, 2021) by gathering the interviewees' perspectives on a topic (Edwards and Holland, 2013) as experts, i.e., persons who hold a certain status or exercise a function in decision-making processes in a particular field of action and, therefore, own specific knowledge of the field of interest (Bogner and Menz, 2009).

This research is based on the exemplary case of SC traceability of Made in Italy products. The Made in Italy refers to high-quality Italian products and has evolved into a brand with a global reputational capital (Schmitz and Knorringa, 2000) that gives the companies exploiting it a competitive advantage in the global market (Festa *et al.*, 2020). Companies of the Made in Italy could use BCT applied to SC traceability for B2C marketing (Violino *et al.*, 2020)Frantoio and Leccino and against counterfeiting (Caldarelli *et al.*, 2020).

Thus, the aim of this study was to collect first-hand empirical data by interviewing managerial and technical staff of Italian SMEs adopting BCT for SC traceability of Made in Italy products and tech companies providing it. The choice to interview both adopters and providers was taken because their insights complete and compensate each other. While the adopters tell their experience as users of blockchain solutions for SC traceability, the providers are able to give better insights on the technical aspects of the blockchain solution they offer and information on multiple use cases from their clients. Even though the providers alone may have given a sufficiently detailed picture of how BCT is used by SMEs of the Made in Italy, interviewing only them could have biased the answers towards exalting the advantages of BCT and belittling its disadvantages, thus it was deemed necessary to interview the adopters too.

A web search was conducted to identify providers and adopters of BCT for SC traceability of Made in Italy products, using keywords both in English and Italian, specifically "Made in Italy", "blockchain", "traceability", "supply chain", and "Made in Italy", "tracciabilità", "catena di fornitura", "filiera". The keywords were not enclosed in quotations to allow for the inclusion of similar terms. Information about providers and adopters was retrieved mainly from online blogs and news articles, which led to identifying a total of 19 providers and 14 adopters.

The providers and adopters identified were contacted for an interview via email, using the contact information provided on their websites. If no response was received, a message was sent to the firm and/or its management on the social media LinkedIn. Six providers and three adopters accepted to be interviewed via calls online or by telephone. The providers interviewed offer blockchain solutions mainly, but not only, to SMEs of the agri-food sector. Of the three adopters, two produce food and one furniture.

The interviewees were assured of anonymity and confidentiality to reduce bias and increase the reliability of the results. The six providers are named P1, P2, …, and P6. The three adopters are A1, A2, and A3. The two tables below show some key characteristics of the providers (Table 1) and the adopters (Table 2) interviewed. All the providers and adopters that accepted being interviewed are micro and small-sized firms, while no medium-sized firms accepted to participate in the study. No additional details about the firms interviewed can be mentioned here without putting their anonymity at risk.

Table 1 Key characteristics of the providers interviewed.

Provider	Type of firm	Size of the firm	Interviewee's role
P1	Startup	Small	Project Manager
P2	Joint-stock company	Micro	Project Manager
P3	Startup	Micro	CEO
P4	Ltd	Micro	CEO
P5	Ltd	Small	Project Manager
P6	Ltd	Small	CEO

Table 2 Key characteristics of the adopters interviewed.

Adopter	Type of firm	Size of the firm	Interviewee's role
A1	Joint-stock company	Small	Marketing Manager
A2	Ltd	Micro	Sales Manager
A3	Ltd	Small	CEO

The interviews took place between November and December 2021 and were 40 minutes long on average. The interviews were semi-structured, with open-ended questions allowing greater flexibility for the respondents to enrich the description of the underlying context, thereby providing a wider picture of the phenomenon under investigation (Seidman, 2006). Expert interviews were based on a topical guide regarding the specific knowledge of the expert in the field of interest (Döringer, 2021). The interviews addressed the following topics: issues in SC traceability that BCT is expected to solve; technical features of the BCT solutions provided/adopted; challenges faced in providing/adopting BCT solutions; collaborations with academic institutions to develop/adopt BCT solutions. The interviews were integrated with follow-up emails to the experts interviewed to gain additional information and to cross-check the findings. The interviewees' answers were grouped by topic and are presented in the findings.

4. Findings

The findings from the interviews describe why and how BCT can be applied for SCs traceability of Made in Italy products. The following paragraphs illustrate the benefits, challenges, technical features, and potential risks for data reliability of the blockchain solutions provided and adopted.

4.1 Benefits

All providers and adopters interviewed underlined that BCT increases data transparency and, consequently, accountability since it is easy to verify who declared what and when, even after a long time, without the risk of such information being tampered with. Accountability safeguards SC partners in case of scandals about their SC: "the attribution of responsibility guarantees the producer because, in case of a scandal regarding its product, the producer can blame the single supplier responsible for providing the false or incorrect information. It also protects the other suppliers from being wrongfully accused" (P5). Accountability can indirectly improve data correctness: "with a blockchain, you cannot edit the information you stored, so you have to be more careful and take responsibility for what you write

[…] the advantage for a company using blockchain technology in its supply chain is that of a higher guarantee that the traceability data is correct" (P5); since data are visible to SC stakeholders and auditable, "companies storing incorrect information on a blockchain would suffer from reputational damage, so they are incentivized to upload the data correctly" (P1).

Transparency and accountability enabled by BCT enable trust between SC stakeholders. Nevertheless, pre-existing trust can make BCT useless: while all providers and two of the three adopters confirmed the role of BCT in creating trust in SCs, A2 stated that "our customers are prevalently local entrepreneurs who know us directly and trust the provenance and quality of our products, so the blockchain for us is not necessary [to build trust in our relationship with them] and gives no advantages from that point of view".

Another advantage of using BCT for SC traceability is anti-counterfeiting. Transparency and immutability of the traceability information stored in a blockchain can help individuate counterfeit products. In centralised traceability systems companies usually use, the traceability information does not often reach the consumer and, even if it does, it can be changed at any time (P5). Instead, with BCT consumers can be involved in anti-counterfeiting activities by giving them the possibility to verify the products' originality (P3). However, this is possible only if the distribution is tracked: "if in the blockchain we put the information about the shop or wholesaler to which it is delivered, together with the status of the product (sold/in circulation), we can guarantee that the goods are authentic to the final customer. If by scanning a tag on a product the customer sees that the product is supposed to be in another shop or that it has been sold already, then she will have the certainty that the product is a counterfeit" (P2). Counterfeiting is an important issue for SMEs of the Made in Italy, in fact, all the providers except for P6 stated that their solution is used against counterfeiting. P3's solution also enables consumers to report the existence of a counterfeit product, which is then blacklisted. As for the adopters, A1 decided to use BCT to give its B2C and B2B customers a guarantee that the company's products are real Made in Italy. This is essential for them since they get much of their revenue from selling abroad to customers who otherwise could not distinguish a Made in Italy product from a fake one.

Using BCT to give SC stakeholders the possibility to verify the products' originality can increase the adopter's revenues. A3 uses BCT because their customers prefer to buy BCT-traced products and pay a higher price compared to products not traced with BCT. All providers and adopters agree that this benefit is especially relevant for high-quality products. All the providers and adopters interviewed use BCT for high-quality Made in Italy products of which consumers value the provenance. Moreover, A3 uses BCT also because distributors are asking companies like theirs to register more traceability information about the entire production process transparently. Companies using BCT to trace their products "can demonstrate the originality and genuineness of their products transparently and benefit from a competitive advantage because large-scale distributors and retailers will prefer to buy from them" (P2).

All providers and adopters remarked that BCT can be used for B2C marketing to promote their products to consumers who value product transparency and as a tool to do storytelling about products. A3 said that "during the Covid-19 pandemic, our company had difficulties connecting to the customers because we couldn't meet them in person, while thanks to the blockchain we were able to reconnect with them by allowing them to learn about our products". Additionally, when consumers scan a tag on a product, they land on a webpage where web analytics software can collect data about their characteristics and preferences that companies can use to make informed decisions (P6). The advantages of BCT for B2C marketing are so relevant, that in the providers' opinion many companies in Italy use BCT for marketing to increase the willingness of consumers to buy their products rather than to enable transparency in SC traceability: "our clients use our blockchain solution mainly for marketing" (P6); "for companies in Italy, blockchain is a matter of marketing to ride the blockchain trend" (P1); "many companies want to use blockchain only for marketing reasons and not for traceability […] [So,] many providers build solutions that provide a good user experience and a suggestive storytelling for a consumer who is not aware of what traceability with blockchain is" (P2).

Finally, BCT enables using smart contracts and NFTs. P2, P3, and P5 use smart contracts to track products and keep together the otherwise scattered information that is uploaded by each partner of a SC on a blockchain. As for NFTs, these can be used to create unique digital representations of assets, trace them, and transfer their ownership between SC partners (P2). Nevertheless, the interviews showed that no providers or adopters use NFTs to tokenize products. P1 uses NFTs only to tokenize documents containing information declared by the producer about its product. P5 states that the complexity of using NFTs to tokenize every single product does not come from BCT, but from the tag printing phase: "you would need a printer that manages to create many labels in a fast way, each having a different QR code identifying a single product". Instead, A3 does not plan to use NFTs to tokenize its products anytime soon, because "the recent hype on NFTs has created a bad reputation around these tools, so using them could damage the image of our company. We will likely use them when consumers can understand their potential".

4.2 Challenges

SMEs of the Made in Italy are getting interested in BCT but are still confused about how to use it in SCs (P5) and do not know its benefits (P4), especially SMEs (P1). Sometimes, they do not want to put their traceability data on a blockchain because they fail to understand the benefits of doing so (P6). For proper BCT-enabled SC traceability, it is necessary that all SC partners put their data on a blockchain (P5). Convincing all the SC partners to be in a blockchain network can be challenging: "it is very complicated to ensure that a product is traced along the entire supply chain. Already for a small artisanal company, nearly fifteen supply chain partners may have to agree to be part of the network and put their data on the blockchain" (P1). Effective communication of what BCT is and the benefits it brings to SCs is crucial to incentivize companies to adopt it. A2 had problems explaining BCT to its suppliers and was unable to communicate the benefits of increased trust, bargaining power towards distributors, turnover, and earnings for all the players involved in the SC. As for the providers, "the problem of technology companies that offer blockchain services is that they focus on creating solutions that are good on a technical level, but then they fail in communicating the benefits to companies" (P3).

Providers diffuse the knowledge on BCT during exhibition fairs and other events. Instead, diffusion by universities remains marginal. While all providers collaborated on blockchain-related projects with universities, none of the adopters found out about BCT from universities. A1 discovered BCT thanks to a consulting company. A2 learned about BCT while having a conversation with a PhD student who was using their company as a case study. A3 became aware of BCT and developed some prototypes thanks to contacts with people they knew for professional reasons.

Apart from the lack of knowledge on BCT, SMEs of the Made in Italy could be reluctant to adopt BCT for SC traceability because of the lack of regulations in Italy, which might be creating a situation of uncertainty. "Regulators should clarify what data must be put on blockchains, in what way, and in what format it must be recorded" (P6). As P5 argued: "if some data are not present on a blockchain, then you cannot say it is traceability" and "the intervention of regulators should ultimately lead to the standardization of the traceability data". Nevertheless, P6 stated: "While there are no laws for traceability with blockchain technology, the blockchain makes up for the lack of regulations because it is built to give a mathematical proof that something was written at a certain time [i.e., it enables data notarization], so in a certain way is replaces laws on traceability".

Another factor that could limit the adoption of BCT is the lack of digitalisation. P5 stated that most companies do not collect traceability data in digital form. A1 declared: "for many of our supply chain partners, traceability is a handwritten paper document that they send to us [as producers] together with the goods. However, the second generation of younger entrepreneurs is starting to use Industry 4.0 tools such as the IoT that allow the automatic collection of data from multiple sources and storage of data in a database shared with us".

Moreover, few companies use management software like ERP that would enable efficient storage of digital traceability data, and that is why some providers offer a BCT solution that can be used as management software (P2, P5). If companies already have internal management software, the providers offer customised integration with their BCT solution. However, P5 notes that "if the company is already using a management software, the software's provider can sometimes ask for up to ten thousand euros to the company to provide the data [necessary for proper integration with blockchain technology]; this is an investment that many SMEs are not willing to make".

4.3 Technical features

Off-chain storage is used by all the providers and adopters interviewed to enable scalability, reduce storage costs, and ensure the confidentiality of sensitive business information. Since off-chain storage exposes to a risk of data loss, the actors holding the data in their private databases are responsible for data retrievability: "the file is uploaded to the cloud database we own, so we are responsible for correctly storing the file" (P4). To enhance data integrity and retrievability, P2, P3, P4, and P5 store the traceability files in the decentralised storage InterPlanetary File System (IPFS). The files' hashes are then uploaded to a blockchain where they are visible to all interested parties. The files themselves can be accessed only by authorised parties that have access to the off-chain database, thus preserving data confidentiality, P1 declared.

Differences in the technical features of the blockchain solutions provided emerged in the architecture used. P4's solution involves a consortium blockchain type, which brings two advantages compared to a public one: the predictability of operational costs, which instead fluctuate in public blockchains, and the fact that known SC partners own the nodes of the network, which are usually not known in public blockchains. However, all providers agreed that companies looking for data immutability should upload their data only on public blockchains. Even in P4's solution, once the data is uploaded on the consortium blockchain it gets aggregated, hashed, and notarized on a public blockchain to ensure transparency against tampering with the data on the consortium blockchain. This hybrid architecture is adopted by A3.

Apart from P4 and A3, all the other providers and adopters use public blockchains only. When asked about the problem of low scalability and lack of data confidentiality of public blockchains, the providers using them replied that these are not critical issues anymore. If a company does not need to make the data visible in real-time, then low scalability is not a problem (P6). If more scalability is required, 3rd generation public blockchains can be used. These are capable of faster data validation at a lower cost, compared to public blockchains of the 1st generation (e.g., Bitcoin) and 2nd generation (e.g., Ethereum). To ensure the confidentiality of data on a public blockchain, the data can be stored off-chain and their hashes on-chain, so that only selected actors in possession of the rights to access the off-chain database can retrieve the data.

4.4 Risks for data reliability

Blockchains make the data almost impossible to tamper with. Nevertheless, the data itself can be incorrect due to human error or fraudulent manipulation. Additionally, the data could be correct but an incorrect version of them could be displayed to stakeholders. Potential sources of unreliable data have been individuated in the interviews.

SC partners could have an interest in declaring false traceability information even if they know it will become immutable and visible on a blockchain. Alternatively, the data could be incorrect because mistakes have been made during the collection or registration of data. All the providers said that nobody can be sure that the data uploaded to a blockchain are reliable and recommended applying the Internet of Things (IoT) so that data about materials, temperature, manufacturing processes, chemical analysis, transportation, and others are automatically collected and uploaded without human intervention.

Further risks of poor data reliability could come from the producers. A product is made of components or ingredients that pass through different stages of a SC, including its distribution. In many of the BCT-enabled solutions provided and adopted, each supplier collects the traceability data about its SC stage and sends them to the producer to be stored in the producer's private database. Then, the producer creates a digital document declaring all the traceability data received by the suppliers, which is then notarized in a blockchain. This BCT-enabled solution could be called "notarization of the producer's declaration". In P2's opinion, this solution does not ensure that the traceability data was not changed by the producer before being notarized on a blockchain.

A further potential source of data unreliability comes from the providers if they are the ones receiving the traceability data from the adopters and uploading them to a blockchain. In this case, the providers act as gateways for the passage of data from the SC partners to the blockchain and have access to them. P1, P4, and P6 collect data from the SC partners and put them on the blockchain.

Instead, P2, P3, and P5 enable SC partners to autonomously put their traceability data on the blockchain, thus enabling more accountability in SCs and avoiding the problem of the data being tampered with by the producer or provider. In this case, SC partners must have and use a blockchain wallet. Also, since the data referring to a product is uploaded to the blockchain by different SC partners at different times, it must be kept together with smart contracts.

Even if the solution involving blockchain wallets and smart contracts could enable more accountability and data reliability, all providers state that the notarization of the producer's declaration is the most adopted BCT-enabled solution by SMEs of the Made in Italy. Indeed, all the adopters interviewed used it. This solution is adopted when it is neither considered necessary, feasible, or desirable that SC partners upload their traceability information autonomously. The lack of necessity of using blockchain wallets and smart contracts to allow adopters to upload data to a blockchain autonomously was underlined by P5, who declared: "even though our solution enables each actor in the supply chain to put the data on the blockchain, it is not always necessary because the producer can put in the data provided by the suppliers". Additionally, using wallets and smart contracts may not be feasible because many companies lack the necessary knowledge to operate and maintain their blockchain wallets (P6). P1 had to replace some digital wallets because their customers lost the access keys of. Finally, there are cases in which the wallets and smart contracts solution is not desirable, as underlined by P1: "sometimes the suppliers are not willing to upload their sensitive data and make them public. In this case, the notarization of the producer's declaration, even with incomplete traceability data, is the only blockchain-enabled solution that a producer can hope to adopt in its supply chain". Moreover, the lack of desirability could be caused by unawareness of what blockchain and traceability are, both from companies and customers. "We, as producers, give the data to be put on the blockchain. The data are not entered by suppliers even if the platform gives this possibility because there is a cultural obstacle to overcome in our suppliers that do not understand blockchain" (A1); "the average entrepreneur has no idea what blockchain and traceability with blockchain are, so they opt for these kinds of solutions" (P2); "the small companies we turn to for some phases of the production process do not understand the blockchain and asking them to enter data on the blockchain would be useless" (A2). Other than the aforementioned factors, the higher desirability of the notarization of the producer's declaration over the wallets and smart contracts solution may depend on why the company wants to adopt BCT. As P6 said, "if the adopter wants the blockchain only for marketing reasons, then a simple notarization of documents containing traceability information by the producer may be sufficient". In fact, according to all providers, most companies in Italy use BCT for B2C marketing rather than to enable transparency in SC traceability, and that is why the notarization of the producer's declaration is the most adopted blockchain solution even though it does not ensure data reliability.

A final risk for data reliability comes from using the provider's centralised App to display the traceability information to SC stakeholders. Most of the BCT-enabled traceability solutions analysed involve a Mobile or Web App as a trusted channel between the user scanning the tag and the information stored in the blockchain. This is deemed necessary because a counterfeiter could apply a tag to its fake product, directing the stakeholder scanning the tag to a webpage containing false traceability information which would induce the stakeholder to believe that the product is original. In this case, BCT could be used by the counterfeiter to store false traceability information, making it visible and immutable and deceitfully increasing the stakeholders' trust that the information is true just because it is on a blockchain. Since the provider's App work only when scanning legitimate tags pointing to the original traceability information, users are safeguarded because scanning the counterfeiter's tag with the provider's App is not possible. However, P2 argues that the Mobile or Web App channel cannot be completely trusted as it runs on a database owned by the provider. The provider or hackers could manipulate the database to display false information on the App's interface. P2 and P3 use a DApp (Decentralised Application) that runs on a public blockchain as a more trustworthy channel. The DApp is a smart contract combined with a front-end user interface. The code that makes the DApp work is stored on the blockchain and is open source, thus it is immutable and visible to whoever wants to audit it. This means that users can know exactly what the DApp does (if they have the necessary programming skills to be able to read the functions written in the DApp). The DApp allows each SC partner, provided with a blockchain wallet, to upload its traceability data on the blockchain. When a user scans a tag to access a product's traceability data, the smart contract of the DApp retrieves the pieces of notarized information that were uploaded to the blockchain by each SC partner and displays them to the user in an organic way. The DApp is more trustable that an App because it "leads the user directly from the tag to the blockchain containing the information on the product, and not to a static webpage where the info can be edited [by the provider] […] moreover, [for us, as providers of a DApp solution,] it would be necessary to attack the entire blockchain to change the traceability data" (P2).

5. Discussion

The interviews conducted showed why and how BCT is used in SMEs for SC traceability, confirming the literature on the topic and adding novel findings about its application to Made in Italy products. The interviewees confirmed that BCT can increase transparency in SCs (Mahyuni et al., 2020) and accountability of SC partners, incentivizing them to upload correct data (Longo et al., 2019). Transparency and accountability enable trust between SC stakeholders (Wang et al., 2019). If trust is already present, then adopting BCT does not bring any additional benefits in terms of trust, as noted by Sternberg et al. (2020) in their case study. Transparency also helps with anti-counterfeiting, as outlined by Hosseini Bamakan et al. (2021). On this matter, BCT is especially useful to protect the Made in Italy brand (Caldarelli et al., 2020). Also, enabling SC stakeholders to verify a product's originality involves them in the process of anti-counterfeiting (Ma et al., 2020), but this only works if the product distribution phase is tracked. The interviewees confirmed the benefit of increased revenues from an increase in sales by customers who value product transparency (Kittipanya-ngam and Tan, 2020) and from persuading them to pay a higher price compared to similar products not traced with BCT (Guido et al., 2020). Traceability with BCT is especially beneficial in the case of products of which consumers value provenance more, as Rogerson & Parry (2020) theorized, such as those Made in Italy. Additionally, using BCT for SC traceability can increase the competitiveness of SMEs because it assures distributors about the products' originality. Another key benefit is that of B2C marketing (Violino et al., 2020): the interviews show that BCT is used by SMEs of the Made in Italy mainly for consumer marketing and to do storytelling about their products. Finally, smart contracts can be used to store the hashes of single traceability events and relate them to a specific product (Chang et al., 2019; Prause, 2019), while NFTs can be used to uniquely identify products and track their change of ownership and related payments, as presented by Chiacchio et al. (2022). However, no providers and adopters use NFTs for these purposes: the bad reputation surrounding NFTs and limits in the speed of label printing were mentioned as barriers to the intention to use them.

As for the challenges to the diffusion of BCT for SC traceability in Italian SMEs, there is a lack of clear legal frameworks on BCT (Iftekhar et al., 2020) and its application to SC traceability, specifically on the standardisation of traceability data (Aung and Chang, 2014). The second problem is the lack of knowledge, as found by Bianchini & Kwon (2020). Effective communication of what BCT is and what benefits it brings is considered crucial to making companies interested in the potential of this technology.

As for the role of public and private academic institutions as knowledge promoters (Hausman, 2012), they do not seem to be active in spreading the knowledge of BCT among companies in Italy. The further challenge deriving from the lack of digital knowledge inside SMEs which limits their capacity to adopt BCT for SC traceability, as theorized by Garrard & Fielke (2020) and Sternberg et al. (2020), was confirmed by the providers. BCT can benefit SCs only if traceability is well-practised by each SC partner, which depends also on the degree of digitalisation of the tracking process (Bumblauskas et al., 2020). However, many companies still use paper documents for tracking, as underlined by Garrard and Fielke (2020). As for the challenge of integrating BCT with the companies' internal business application software such as ERP, mentioned by Tan & Ngan (2020) and deemed problematic by Al-Jaroodi & Mohamed (2019), this did not emerge as an issue since all the providers interviewed offer such integration. However, for successful integration, the adopter must first have control of the data stored in its internal management software, which is not always the case and could be very expensive for adopters to obtain from the management software provider.

Regarding the technical aspects of the solutions analysed, all providers and adopters implement off-chain storage to provide scalability and data confidentiality, as advised by Shahid et al. (2020) and Behnke and Janssen (2020). To increase data integrity, some interviewees store data off-chain in peer-to-peer decentralized databases (Shahid et al., 2020) such as IPFS (Salah et al., 2019). One provider and one adopter use a hybrid blockchain combining a consortium blockchain for scalability (Dib et al., 2018) and data confidentiality (Bumblauskas et al., 2020; Chan et al., 2019; Mao et al., 2018) with a public blockchain for data immutability, similar to that proposed by Wu et al. (2017). Instead, most providers use only public blockchains. Scalability is not an issue because they use 3rd generation public blockchains, while data confidentiality is ensured with off-chain storage. Hence, the benefits of permissioned blockchains can be obtained by combining 3rd generation public blockchains for enhanced scalability with off-chain storage to ensure data confidentiality.

Finally, this research found some risks to the reliability of the traceability data in certain BCT solutions. The primary source of data incorrectness can be any SC partner. Nobody can be sure that the data provided by SC partners is correct, as noted by Violino et al. (2020). The providers recommended using the IoT to automate the collection and upload of traceability data to a blockchain to remove any human intervention in these processes, as proposed by Iftekhar et al. (2020). Other sources of data incorrectness could come from the producers or the providers if they are the ones responsible for uploading to a blockchain the traceability data they receive from the SC partners since they could manipulate or omit data before storing it. The BCT-enabled solution of the notarization of the producer's declaration brings these risks, whereas using blockchain wallets and smart contracts to allow every single SC partner to upload its data autonomously eliminates them. Even if the latter solution increases data reliability, the former is the most adopted in Italy when it is not necessary, desirable, or feasible that each SC partner uploads its traceability data on a blockchain, for reasons that include a lack of awareness on BCT and traceability and lack of knowledge on how to use and maintain a blockchain wallet. Moreover, many companies in Italy use BCT for B2C marketing reasons rather than to enable transparency in traceability, thus the notarization of the producer's declaration might be sufficient for their scope. A final risk for data reliability could come from the providers showing on their App's interface different information than that stored on a blockchain. Some providers use a DApp running on a public blockchain to create a direct connection between the user and the data on the blockchain. Thus, DApps might enable more transparency, accountability, and trust in SCs, compared to Mobile or Web Apps.

6. Conclusions

In recent years, BCT has been proposed as a tool for increasing transparency and accountability in SCs. Researchers have addressed the benefits and challenges of using BCT in SCs, but there is a need for more evidence based on real applications. To address the lack of empirical data and building on the assumption that SMEs of the Made in Italy could benefit particularly from using BCT for SC traceability, this research aimed at collecting first-hand data from expert interviews with managerial and technical staff of Italian SMEs adopting BCT for SC traceability of Made in Italy products and tech companies providing it.

This research tries to answer two questions: what issues of SC traceability of Made in Italy products can BCT address (RQ1), and which blockchain solutions for SC traceability can SMEs of the Made in Italy use, according to their objectives (RQ2)? The findings are grouped by topic, describing the benefits, challenges, technical features, and risks for data reliability in the use of BCT for SC traceability in SMEs of the Made in Italy. As for RQ1, this research confirms the results of other studies on BCT for SC traceability which have been addressed in the discussion. BCT can be used for SC traceability to increase transparency and accountability, thus improving trust among SC stakeholders. BCT can help firms of the Made in Italy to fight counterfeiting and promote their products. Some challenges remain, namely the lack of digital knowledge in firms, clear regulations, and consumer awareness of the advantages of BCT-enabled traceability. Regarding RQ2, this research introduces some novel findings regarding how BCT for

SC traceability is used by SMEs of the Made in Italy: a) public 3rd generation blockchains combined with off-chain storage to provide transparency, scalability, and data confidentiality are mostly used, while the use of permissioned blockchains is marginal; b) BCT-enabled traceability is used mainly for B2C marketing; c) the most adopted BCT solution for SC traceability is the notarization of the producer's declaration, while using blockchain wallets and smart contracts to enable every SC partner to upload its traceability data to a blockchain is much less used despite bringing more accountability in SCs.

Some managerial implications can be suggested. The study provides valuable information to SMEs to understand if they need a BCT solution in their SC and what solution fits their needs. In other words, firms can use the results of this study to answer the questions of "why does the firm need BCT?" and "what BCT solution is the most suited to the firm's needs?". As for the "why" question, BCT is useful in situations where there are multiple parties that want to share data among them (e.g., products' traceability data shared among SC stakeholders) but do not trust each other with data handling (i.e., safely storing the data and ensuring that it will not be modified or cancelled) and cannot or do not want to find a trusted third party to handle the data. Thus, firms should first assess if trust is missing among the stakeholders involved in their SCs. If trust among them is present, BCT will not be useful. The firms interviewed use BCT to enable trust in their SC for B2C marketing purposes. Their assumption is that consumers would prefer to buy a product traced with BCT because they would trust the firm more for storing the product's traceability data on an immutable and visible database such as a blockchain. This positive effect was also mentioned by the providers interviewed. However, firms should be aware that there is no clear evidence yet of the profitability of using BCT to increase the willingness of consumers to buy BCT-traced products or pay a premium for them. Specifically, there has not been extensive research benchmarking the benefits and costs of using BCT for SC traceability compared to other existing non-blockchain technologies that enable traceability in SCs and allow consumers to access traceability data by scanning a tag on a product's label. If the firms decide to use BCT in their SCs, they need to answer the question of "what" BCT solution to adopt based on their needs. Firms that want to use BCT just for B2C marketing purposes may find it convenient to adopt a simple blockchain solution allowing the notarization of documents stating the products' traceability information, which is accessible via the provider's App. This solution poses some risks to data reliability, so it is not the most suited to create trust among SC stakeholders. Instead, if the main objective is to enable trust among SC stakeholders, then the blockchain solution adopted should ideally have all the following characteristics: a) all SC partners should be able to upload their traceability data to the blockchain autonomously, without needing to send the data to an intermediary that uploads them; b) the hashes of the traceability data should be uploaded to public blockchains that are not owned by anyone and are beyond anyone's control; c) the IoT should be used to automatically collect traceability data from their sources and upload them on the blockchain without human intervention; d) if the blockchain solution's provider is not trusted, a decentralised application (DApp) should be used to write and read the traceability data to and from a blockchain. These aspects call for two considerations. First, all SC partners must be willing to be involved in the blockchain traceability solution to upload their traceability data to the blockchain themselves. Otherwise, the producer or the provider must be the ones gathering the traceability data and uploading them on the blockchain, exposing to the danger of data manipulation by these actors. Second, since on-chain storage is not possible due to the low scalability of public blockchains, firms need to define who is responsible for correctly storing the data off-chain and ensuring that it is always accessible. Usually, this role is covered by the blockchain solution's provider, but this solution reinstates centralisation in situations where decentralisation enabled by BCT is desirable to create trust. Indeed, in such situations, the provider is a third party that is trusted with handling the traceability data. If the provider is not trusted, then a DApp may be a more trustworthy tool than the provider's App to write and read the traceability data to and from a blockchain.

This research faces three main limitations. First, it is a qualitative research based on a small sample of six providers and three adopters from Italy, so the results cannot be generalised. Second, interviewing the providers of the BCT solutions for SC traceability in Italy may have biased the answers towards exalting the advantages of using BCT and belittling its disadvantages; however, this bias was mitigated by interviewing the adopters too. Third, although the objective of this study was to gather evidence from SMEs, the adopters and providers that accepted being interviewed were all micro and small-sized firms, so no medium-sized firms were interviewed. Thus, all evidence collected on the use of BCT for SC traceability by Italian medium-sized enterprises comes from the declarations made by the providers and cannot be checked against those from medium-sized adopters.

Based on the key findings of this research, future research should integrate the results by systematically comparing the cost and benefits in terms of increased revenues of the different blockchain-enabled solutions individuated in this paper. This would give companies more relevant information to understand the profitability of the different blockchain solutions and what profit margin they need to cover the costs of implementing BCT in their SC. Additionally, researchers should address the implications of adopting BCT for SC traceability for the adopters' competitive strategy. It would also be of interest for researchers to investigate what the perception of NFTs is among companies and see how it affects the choice of providers and adopters to use them or not. All these studies should consider the differences between firms in sector and size. Longitudinal case studies could be developed to follow the evolution of the implementation and use of BCT in SMEs throughout time. Moreover, evidence is needed on whether, how, and to what extent the lack of clear legal frameworks is limiting the diffusion of BCT for SC traceability, also providing a comparative analysis between different countries.

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