Blockchain, logistics and omnichannel for last mile and performance

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Abstract

Purpose – This research investigates the effects that blockchain exerts on omnichannel solutions and logistics strategies with the aim of solving the last mile issues and improving performance.

Design/methodology/approach – Research hypotheses are developed according to the literature review and the related gaps. Then, the hypotheses are tested using structural equation modelling and adopting a partial least squares – path modelling technique on a dataset composed of 157 firms.

Findings – Blockchain technology alone is not an effective driver in solving last mile issues and improving performance. Rather, it exerts a positive contribution to both omnichannel and logistics. However, omnichannel is not effective in managing last mile problems and increasing performance without the support of other practices. Firms need to implement a strong logistics system to manage the last mile and get high performance, which can be then reinforced through blockchain and omnichannel solutions.

Originality/value – This research investigates the novel wave of research on blockchain and its impact on logistics management and omnichannel. It combines these ingredients to address the issues of last mile and improve the economic performance. The research provides an empirical verification of a new research stream that currently lacks empirical support.

Keywords Blockchain, Logistics, Omnichannel, Last mile, Performance

Paper type Research paper

1. Introduction

Today's companies interact in an ecosystem that undergoes profound and rapid transformations, driven by digitalization and technological developments (Lim *et al.*, 2018). E-commerce, the Internet of things, artificial intelligence, blockchain, crypto-payments, robotics, clouds, big data and augmented reality are only some of the challenges that characterize the modern economy. These phenomena require the development of new managerial paradigms, which drives changes in business models and global strategies (Koh *et al.*, 2019). In this landscape, blockchain complements existing practices and technologies to solve important business issues (e.g. lack of transparency and trust (Manupati *et al.*, 2020), visibility and information sharing (Martinez *et al.*, 2019), frauds and counterfeit products (De Giovanni, 2020), fake information and news (Capgemini, 2018a), risk of centralized information and errors (Dobrovnik *et al.*, 2018).

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Until recently, blockchain was most likely used for managing financial services efficiently and finalizing transactions securely. However, business applications are continually increasing (e.g. integration with RFDI (van Hoek, 2019), product traceability and security (Martinez *et al.*, 2019), incentive mechanisms and smart contracts (Rejeb *et al.*, 2021). See Vivaldini (2021) for an overview of case studies and applications. Within this framework, our contribution investigates the effects that blockchain has on omnichannels and logistics. The primary objective is to solve the last mile issues and improve performance. The last mile represents a real problem for firms. According to a recent business report by Capgemini (2018a), last mile is the biggest cost driver of the supply chain, weighting about 41% of the total. Hence, firms seek to successfully manage the last mile to achieve high performance and outcomes. Omnichannel solutions and logistics strategies can be effective drivers to mitigate last mile issues (Lim *et al.*, 2018). The integration of all channels allows firms to offer different opportunities for consumers to be satisfied. This is an effective practice when managing the last mile is problematic (Lim and Srai, 2018).

Furthermore, a strong logistics network can effectively solve the last mile issues (Lim *et al.*, 2018). The adoption of blockchain technology can boost both omnichannels and logistics to better solve the last mile issue and improve performance. Consequently, we carry out an empirical contribution to verify the direct implications that blockchain has on last mile issues and performance and by exploring the indirect benefits it exerts through omnichannel and logistics. We develop research hypotheses to link these ingredients and test them using Structural Equation Modelling through Partial Least Squares-Path Modelling techniques on a sample of 157 firms.

Our findings show that blockchain is a valuable option to reinforce both the omnichannel strategies as well as the effectiveness of logistics. We also demonstrate that blockchain alone is not a suitable technology to solve the last mile issues and increase performance. To be highly effective, blockchain requires well-structured and highly-performing logistics through which companies can fully exploit the technology potential. Similarly, an omnichannel is not a suitable driver for improving the last mile, even though blockchain allows firms to better integrate the channels and pursue successful omnichannel solutions. The synergies existing between blockchain and omnichannel can boost the logistics potential, which is the main driver for managing the last mile and achieving outstanding performance. Put differently, firms cannot rely on blockchain and omnichannel solutions to solve last mile issues and improve performance. Rather, they should look at blockchain as a general-purpose technology, which complements the existing systems and improves their effectiveness.

The remainder of this paper is structured as follows. In Section 2, we review the literature on the variables investigated and present the hypotheses. In Section 3, we describe the data collection process and test the hypotheses. Section 4 is dedicated to the discussion, the managerial implications, and the theoretical contributions. Finally, Section 5 presents the conclusions, the limitations, and the possible extensions.

2. Literature review and hypotheses development

Firms' tendency to integrate offline and online channels to provide a seamless customer experience finds its roots in continuous technological development (Levy *et al.*, 2013; Brynjolfsson *et al.*, 2013), the rapid changes related to consumer purchasing habits (Yurova *et al.*, 2016) and the benefits that omnichannel offers in terms of sales growth (Ishfaq *et al.*, 2016), brand loyalty, and customer satisfaction (Chen *et al.*, 2018). The literature has deeply detailed the possible advantages and potential applications of omnichannel (Brynjolfsson *et al.*, 2013; Grewal *et al.*, 2017; Abrudan *et al.*, 2020). Through successful cases and evidence (e.g. Tesco and Macy's (Tetteh and Xu, 2014)), firms are still struggling with the implementation of efficient and successful omnichannel strategies (Lim and Sria, 2018). Companies operating in an omnichannel context deal with high supply chain complexity. Most problems that emerge from omnichannel strategies are linked to the lack of transparency (Abeyratne and Monfared, 2016) and the need for fast deliveries, flexible orders and compliance with regulations or quality standards (De Giovanni, 2020), as well as several types of risks that can lead to lower customers' satisfaction and purchasing intentions (Ma, 2017).

Blockchain technology can be an effective solution to the current issues existing in the omnichannel frameworks. Blockchain is "a distributed digital ledger of transactions that cannot be tampered with due to the use of cryptographic methods" (Pilkington, 2016). This system benefits from both the absence of a central authority replaced by a peer-2-peer-network, a public-private-key cryptography, as well as a consensus-based algorithm (Rejeb *et al.*, 2021). This allows for the validation of a new block of transactions, but only if member consensus is reached. These three elements make blockchain a decentralized, verified, and immutable system, providing the basis for its potential business benefits. Although blockchain results in several applications and heterogeneous executions, it is still in its early phase of development in SC management (De Giovanni, 2020).

Firms looking at the development of an omnichannel strategy can evaluate the adoption of blockchain to mitigate all SC inefficiencies. The literature has highlighted how blockchain can enhance the economic and operational value of all the activities across the SC (Ksherti, 2018), from manufacturing to warehousing (De Giovanni, 2021), transportation and logistics (van Hoek, 2019) and global sourcing and smart contracts (De Giovanni, 2020). By implementing blockchain technology, all partners involved in the network (e.g. retailers and customers) share the same verified information, allowing for the optimization of the omnichannel strategy and eliminating the need for trust and transparency among omnichannel parties.

Indeed, the blockchain can be helpful for implementing successful omnichannel strategies when supported by other digital technologies. This evidence is corroborated by the empirical study by Popescu *et al.* (2021) according to which the integration of cross-channel processes and data is a key ingredient to guarantee cooperation between digital technologies and businesses. On the same vein, Ionescu (2019) empirically demonstrates that cloud-based accounting supports the access to blockchain, making firms able to access all recorded transactions. Also, the artificial intelligence embedded within the clouds allows firms to screen the information, given the high number of transactions recorded on the blockchain. This mix of technologies guarantees financial transparency and enables immediate interventions. In a more general analysis based on several consulting reports, Nica *et al.* (2021) analyze the impact of digital technologies in the next ten years. Accordingly, IoT sensors, in combination with blockchain's distributed ledger, will provide end-to-end visibility throughout the supply chain and transportation network in 80% of the businesses. Therefore, blockchain will become a very popular platform within the digital technologies adopted by supply chains, while the related competitive advantages will clearly decrease proportionally to its maturity (Davis *et al.*, 2020). Overall, the integration of digital technology is a fundamental step to ensure data-enabled resource optimization (Kean *et al.*, 2020) and requires ad hoc platforms to properly engage consumers and develop long-term relationships (Gaffney, 2020).

Some business cases have already demonstrated the success of using blockchain technology to improve omnichannel. Walmart used blockchain technology to increase the transparency of its food supply chain, enabling full product traceability over the globe and across all multi-channels used (Karmath, 2018). Initially, this system was tested to track the origin of mangoes sold in its stores in America and to monitor pork sold in its Chinese stores. In the former case, the result was a considerable reduction in the time needed to check the origin of the mangoes. Instead of taking seven days, it only took 2.2 s. This improvement allowed the sales of mangoes to quickly develop in all SC channels. In the latter case, blockchain allowed for the uploading of the certificates of authenticity attesting to the quality of the meat for all stakeholders and consumers purchasing the products in all channels.

Apart from the food chain, blockchain is also gaining ground in the fashion world. The challenge here is the risk of counterfeit products. This is the reason why companies, such as LVMH, are experimenting with the use of blockchain (e.g. Louis Vuitton), to allow consumers to trace the entire history of the products, from the raw materials used, to the manufacturing and distribution. Blockchain can then boost the use of omnichannel solutions for selling goods (Choi, 2019).

The aforementioned examples highlight how blockchain streamlines the processes in an omni-distribution channel environment. These cases also demonstrate how blockchain becomes the cornerstone of the entire omnichannel consumer experience, making it stimulating, secure, simple and agile, also within the context of social media (Choi *et al.*, 2020). Although blockchain is a potential technology used to improve omnichannel strategies, there is still a lack of evidence and empirical research highlighting its true operational and economic benefits. Accordingly, we hypothesize that:

> H_1. The adoption of blockchain technology has a positive impact on both the implementation and the management of an omnichannel strategy.

The enthusiasm generated by the high expectations linked to blockchain is partly held back by the absence of the sufficient practical evidence of its advantages. Being a rather new technology, there is little knowledge and there is also confusion about its possible applications, especially in logistics (Dobrovnik *et al.*, 2018). Logistics is the strategic management of the movements and storage of raw materials, semi-processed materials and finished products from suppliers, through the focal company and the consumers (Christopher, 2016). It encompasses a very diversified portfolio of business activities ranging from inventory management, order fulfilment, warehousing and the management of third-party logistics services providers (Rejeb *et al.*, 2021). It also includes production planning, scheduling and customer service activities.

The blockchain mechanism enables the monitoring of a product throughout the supply chain, ensuring that data are stored as transactions, visible to all members and verifiable without the need for intermediation (Dobrovnik *et al.*, 2018). Thereby, collaboration among all stakeholders in the SC is enhanced by full information sharing and full visibility (Manupati *et al.*, 2020). In this way, time-consuming and expensive logistics processes can be speeded up, streamlined, and made more secure. These risks can push SC members to search for a full integration strategy with the SC members, especially when the core business is harmed (Sabet *et al.*, 2017). The use of smart contracts, for instance, promotes compliance with agreements between the parties and accelerates payment procedures (De Giovanni, 2020). Nevertheless, the literature has expressed concerns about the application of blockchain. Francisco and Swanson (2018) explains that the benefits of blockchain are especially evident with increasing number of members. Shermin (2017) points out that it is complex for companies with different levels of technology to collaborate on blockchain implementation. Dobrovnik *et al.* (2018) highlights possible problems that can occur among SC partners at the regulatory or consensus level. This dichotomy between the difficulties linked to the issues of establishing blockchain and the potential operational benefits, together with the lack of their empirical evidence, induce us to hypothesize that:

> H_2. The adoption of blockchain technology has a positive impact on both the implementation and the management of a logistics strategy.

Blockchain is expected to be one of the key drivers in improving the omnichannel strategy. MacCarthy *et al.* (2019) and Lim and Sria (2018) illustrate how the wave of technological progress, characterized by the advent of the Internet, as well as the emergence of mobile phones and of social networks has stimulated companies to explore the use of new sales channels. Defining as a multichannel, this approach consists of companies operating different channels, which are independent from each other (Beck and Rygl, 2015). These channels are most likely as separate silos, not exchanging information and having their own separate operational and logistical processes (Hübner *et al.*, 2016). Consequently, the synergies due to the single, integrated and data-driven management of channel activities are not exploited and drawbacks like cannibalization arise. Academics agree that multichannel operational deficiencies can be solved by switching to omnichannel.

Brynjolfsson *et al.* (2013) explains that this approach facilitates fulfillment processes by eliminating barriers among channels, thereby enabling communication across them and the creation of a unique set of operations, logistics, and inventory. Hübner *et al.* (2016) also developed a comprehensive framework that highlights the enhancements that an omnichannel logistics system can bring in the areas of forward and backward distribution, inventory management, picking across channels, assortment and identifying ICT and organizational systems as fundamental for an efficient and effective logistics integration.

Although the literature is quite unanimous on the advantages offered by omnichannel in logistics management, the studies also illustrate the problems of an omnichannel logistics system. Weiland (2016) explains how full integration between the channels and the agility of logistical processes can only be achieved through reliable and secure data shared with all SC members. Furthermore, there is a need to integrate all of the channels to ensure the harmonious development of all channels simultaneously. Hübner *et al.* (2016) points out omnichannel cost related problems due to the necessarily large capital investments in technologies, expertise and resources. Larke *et al.* (2018) focuses on how an omnichannel implementation strategy is a very time-consuming project, requiring substantial changes throughout the SC and involving significant challenges.

The discrepancy between the advantages and disadvantages provided by omnichannel for logistics strategies, together with the small number of examples of companies that have fully and successfully implemented logistical interfaces among channels (Grewal *et al.*, 2017), induces us to better explore this field. Accordingly, we hypothesize that:

H_3. A successful omnichannel has a positive impact on both the implementation and the management of a logistics strategy.

One of the primary and toughest issues that logistics managers have to master is the handling of the last mile phase. Lim *et al.* (2018) depicts the last mile as "the last stretch of a business-to-consumer parcel delivery service, taking place from the order penetration point to the final consignee's preferred destination point." In other words, it means delivering the product into the consumer's hands, regardless of the channel through which the product was purchased (e.g. company website, retailer store) and the delivery destination (e.g. home, office, locker) (De Giovanni, 2021).

The last mile has gained significant interest from scholars, especially during the last few years. However, due to the growth of e-commerce, the academic research has not refrained from analyzing it from different perspectives. Notably, the literature is attempting to answer to the necessity of making the last mile delivery as efficient as possible.

The use of parcel lockers, placed, for example, in buildings or shops enables the customers to pick up their products safely where they prefer to and at their most convenient time (e.g. Amazon). New solutions, such as crowdsourcing logistics (Wang *et al.*, 2016) or collection and delivery points (MacCarthy *et al.*, 2019) have also been introduced by companies. Advanced technology vehicles are perceived as a possible answer to last mile inefficiencies. Deng *et al.* (2020) propose the introduction of drones to effect deliveries and to decrease the number of unfulfilled deliveries.

The literature suggests the optimization of the traditional delivery method to achieve last mile efficiency. Abdulkader *et al.* (2018) frames the issue of finding the optimal route within an omnichannel system. Beyond the logistical efficiency, some authors highlight how a well-managed last mile can increase consumer satisfaction and loyalty (Chou and Lu, 2009). Others underline the problems related to the environmental sustainability of online commerce (Bertram and Chi, 2018).

From what has been said, it is evident that the careful planning of last mile logistics is of interest to companies and consumers (Lim *et al.*, 2018). Indeed, the optimal management of the last mile process can mitigate those shortcomings (e.g. transportation costs, delivery costs, delays, missed deliveries). It can also translate into higher economic performance and customer-related advantages (e.g. brand loyalty). Within this context, our goal is to demonstrate that the logistics system can be the key to make the last mile delivery process as efficient and manageable as possible. Accordingly, we hypotheses that:

H_4. A successful logistics strategy has a positive impact on both the implementation and the management of last mile delivery solutions.

For those players active in the marketplace through e-commerce (e.g. Amazon, Alibaba), setting up and controlling all the processes linked to the last mile are crucial points. Hübner *et al.* (2016) identified four variables shaping the last mile dimension and the issues associated with each of them: delivery mode, delivery time, delivery area and return logistics. The former denotes all the procedures that a company can carry out to provide the product to its customers. This includes attended home delivery, unattended home delivery, reception box, collection-and-delivery points and crowd shipping. The optimization of the delivery time is one of the cornerstones of last mile management. Its efficient planning translates into higher customer satisfaction and effective cost reductions (Bushuev and Guiffrida, 2012). Firms have to take into account both the internal factors (e.g. optimal delivery windows offer) and the external factors (e.g. travel time uncertainty) (Agatz *et al.*, 2011).

The last mile logistics have to be designed in relation to the area in which the delivery service is to be executed. Zeng (2018) points out that, despite the continuous expansion of e-commerce in China's rural areas, the last mile still represents a serious hurdle. This is due to inadequate infrastructure, the insufficient participation of logistical operators that are distant from each other and that work with a poor technology system, resulting in significant costs. Bell *et al.* (2014) indicates that the introduction of "buy online, pick up in-store" has triggered a decline in online sales and an increase in offline sales within the American market, especially for those items whose attributes are complicated to sense virtually. Identify the marketing and operations challenges linked to the implementation of an omnichannel strategy and the related key decisions that firms must take. Among those, designing of fast last mile delivery has a great importance to perform from both a consumer perspective (e.g. consumer convenience and choice, reliability, sales expansion) and an operations perspective (e.g. low cost, sustainable supply). Therefore, omnichannel strategies can expand the segment of clients not choosing home delivery, slimming last mile operations. This potential enhancement, provided by omnichannel, has no evidence and empirical research demonstrating its effectiveness. Accordingly, we hypothesize that:

H_5. A successful omnichannel has a positive impact on both the implementation and the management of last mile delivery solutions.

While omnichannel promises to reduce the criticalities and the uncertainties connected to the last mile, a more tangible answer is already being given by the technology (De Giovanni and Cariola, 2020). The growing pace of the technological progress has pushed companies to invest in new solutions and mediums to operate the delivery chain. A comprehensive overview of the cutting-edge gimmicks, their strengths and their cost-effectiveness has been provided by Mangiaracina *et al.* (2019). Accordingly, the employment of increasingly advanced robots, in conjunction with new delivery techniques (e.g. mapping customer behavior, dynamic pricing) is deeply modifying the last mile outlook.

Schröder *et al.* (2018) forecast that over the next twenty years there will be a gradual adoption of sophisticated, and probably disruptive, technologies which will revolutionize last mile delivery. One of the most promising strategies to solve the last mile management problems is the use of blockchain technology. The literature is currently quite silent in this regard. The examination of some practical examples and some scholars' research can be considered a starting point to foresee the future possible applications of blockchain in the last mile.

Pournader *et al.* (2019) consider blockchain as a useful driver for establishing trust between all partners. This can come into play in transporting and delivering goods (e.g. third services logistics providers), enabling a common sharing of accountable transaction data. To reduce costs and delivery times, Walmart has filed a patent for a blockchain-based drone system (Hanbury, 2019). The idea is to use blockchain keys to allow drones to exchange information with each other and with other delivery vehicles to enable them to swap parcels, eliminating the need for paperwork and improving package tracking transparency and delivery security (Karmath, 2018).

Last mile delivery problems can also stem from the traceability of the product. For products that are easily perishable (e.g. foodstuff), the delivery has to be properly planned and managed. Companies must ensure that consumers receive their purchases in optimal conditions. By using blockchain, SC partners can have access to a reliable and secure record of data transactions and monitor the status of the product step-by-step, going back to the origin of the inefficiencies more quickly. Applying this, IBM (2018) gave life to the IBM Food Trust, aimed at "making the food safer and smarter from farm to fork."

The cases illustrated are proof that blockchain technology can be a powerful aid in successfully handling last mile operations. More in general, the blockchain technology supplies benefits any time the quality of data is poor (Choi and Luo, 2019) by connecting the physical to the digital world (De Giovanni, 2020). Nevertheless, the obstacles and doubts related to its application and functioning leads companies to still be uncertain and reluctant about its effectiveness (Francisco and Swanson, 2018; Shermin, 2017). Therefore, even if blockchain is a potential technology that can be used to improve the last mile phase, there is still a lack of evidence and empirical research highlighting its true benefits. Accordingly, we hypothesize that:

H_6. The adoption of blockchain technology has a positive impact on both the implementation and the management of last mile delivery solutions.

Offering home delivery services is a common practice for those purely e-commerce businesses. Nonetheless, a continuously growing number of companies selling offline are now moving into the virtual sale world. They are aligning their traditional channels with the digital ones to grab a profitable slice of the online buyers (Ishfaq *et al.*, 2016). Firms' efforts of becoming omnichannel are motivated, among other things, precisely by the chance of thriving economically in a strongly changing market environment.

A Briedis *et al.* (2019) apparel industry report reveals that omnichannel shoppers account for 30% of the total number of consumers. D'Arpizio and Levato (2021) introduced the expression "phy-gital" to connote the actual luxury goods purchased by consumers, estimating an increase in the use of online channels of 22% by 2020 in this sector. The ways of purchasing groceries is under a continuous digitalization, with retailers more and more committed to fulfilling online sales (Wollenburg *et al.*, 2018).

The changeover to omnichannel, to exploit its economic benefits, cannot take place without substantial changes. Berman and Thelen (2018) explain that an efficient, effective and profitable omnichannel strategy is fully accomplished when companies handle their channels in a homogeneous way by offering several different shopping options (e.g. buy online/pick up in store, buy online/home delivery, buy online/return to store). To ensure such services do not turn from a profit opportunity to insurmountable costs, firms require scrupulous and meticulous planning of logistics and operations.

The literature is broadly in agreement about the essential role played by logistics in driving corporate profitability. Christopher (2016) argues how the management of the corporate logistical system is a strategic factor necessary to achieve a competitive advantage and profitability. Miller and Liberatore (2015) carried out an extensive investigation on a large sample of firms to analyze the way they manage outbound logistics to demonstrate how it affects profitability. De Giovanni (2019b) stresses the importance of minimizing costs by optimizing and managing the inventory accordingly.

Researchers are mainly concerned about the high operating costs and the challenges involved with the last mile logistics. Lim *et al.* (2018) classify delivery processes among the most expensive and inefficient in the entire SC, and therefore, among the most damaging for profitability. Vakulenko *et al.* (2019) highlight the struggle and the expense to satisfy omnichannel customers, offering customized delivery services in terms of delivery times, locations, and payment methods, as well as granting them optimal returns conditions. Nevertheless, a well-managed last mile can be a key element in building customer loyalty and encouraging repurchasing (Capgemini, 2018a, b).

The literature is also exploring how new technologies (e.g. blockchain) can contribute to companies' economic survival in the omnichannel scenario. Ko *et al.* (2018) empirically demonstrates how blockchain technology, enabling real-time transparency and the reduction of costs (e.g. eliminating the necessity of paperwork) can improve the overall business profitability. De Giovanni (2019a) emphasizes the economic and operational benefits of blockchain across SC. Likewise, however, the literature still lacks sufficient practical cases to prove the effectiveness of blockchain. Within this context, we want to contribute to the existing literature by providing empirical support on how the aforementioned elements (i.e., omnichannel, logistics, last mile, blockchain) can positively influence the firms' economic performance. Accordingly, we hypothesize that:

H_7. A successful omnichannel has a positive impact on the economic performance.

H_8. A successful logistics strategy has a positive impact on the economic performance.

H_9. A successful management of the last mile has a positive impact on the economic performance.

H_{10}. The adoption of blockchain technology has a positive impact on the economic performance.

2.1 Hypotheses on the indirect effects

The conceptual model that we propose in Figure 1 displays also the existence of indirect effects, which are the second order effects complementing the original analysis. According to these effects, we hypothesize that:

H_{2b}. The adoption of blockchain technology has a positive indirect impact on both the implementation and the management of a logistics strategy.

H_{5b}. A successful omnichannel has a positive indirect impact on both the implementation and the management of last mile delivery solutions.

H_{6b}. The adoption of blockchain technology has a positive indirect impact on both the implementation and the management of last mile delivery solutions.

H_{7b}. A successful omnichannel has a positive indirect impact on the economic performance.

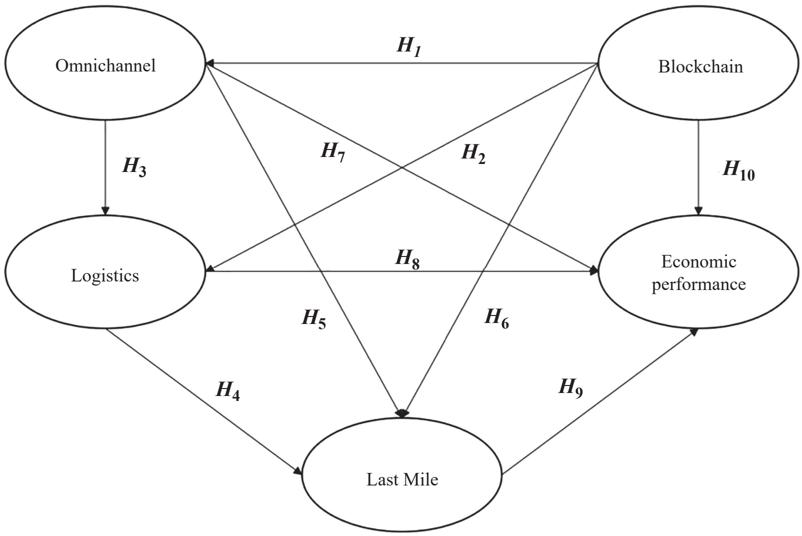

Figure 1. Conceptual model

H_{8b}. A successful logistics strategy has a positive indirect impact on the economic performance.

H_{10b}. The adoption of blockchain technology has a positive indirect impact on the economic performance.

3. Methodology

3.1 Survey design and sample description

To test our research hypotheses, we designed a survey to collect information about the respondents (e.g. industry and company type), the investments in blockchain technology, the implemented omnichannel strategies, the logistics strategies, the last mile management and the performance. The following step consisted of pre-testing the questionnaire on a pool of experts (e.g. professors, Ph.D. students, professionals, managers) from whom we asked for feedback about wording, readability, and completeness. Consequently, the survey was modified and improved accordingly. The data collection process began by subjecting the survey to an initial sample of 1,200 firms' managers. Because our research focuses on supply chain management, we chose to interview professionals who are active in this domain. They were contacted via email. Within two weeks, we received the majority of the responses. In the meantime, we extended our investigation by contacting them by phone. Overall, we obtained a total of 157 useable observations, excluding those removed as invalid. This represents about 12% of the entire population of companies that we targeted (1,200). The sample primarily constituted large enterprises, both in terms of sale turnover and employees. More than half of the organizations had an average sale turnover of more than 100 million (52%) and a workforce of more than 200 employees (53%).

The data collected was primarily from European and American companies, 73 and 16%, respectively. Most of the interviewees are supply chain managers (52%), working mainly for manufacturing companies (36%) and retailers (23%). The results reveal a heterogeneous industrial panorama with the Food and Beverage (22%) and the Fashion and Apparel (12%) sectors predominating. A more detailed representation of the distribution of the respondents and the composition of the sample characteristics are illustrated in Table 1.

Table 1.
Sample description

Sales	#	%	Country	#	%	Company type	#	%	Professionals	#	%	Industry	#	%
<10	11	7.0	Europe	115	73.2	Manufacturer	56	35.7	SC Manager	82	52.2	Food and Beverage	34	21.7
10–50	38	24.2	USA	25	15.9	Wholesaler	30	19.1	Logistics Manager	12	7.6	Fashion and Apparel	18	11.5
50–100	26	16.6	Asia	4	2.5	Distributor	14	8.9	Operations Manager	13	8.3	Medical and Healthcare	12	7.6
>100	82	52.2	Other	13	8.3	Supplier	21	13.4	Sales Manager	3	1.9	Automobile	11	7.0
						Retailer	36	22.9	Production Manager	9	5.7	Mechanic	7	4.5
									Purchasing Manager	2	1.3	Energy	7	4.5
									Procurement Manager	8	5.1	Furniture	6	3.8
									Distribution manager	2	1.3	E-commerce	5	3.2
									Other	26	16.6	Aerospace	4	2.5
												Sport	4	2.5
												Entertainment	4	2.5
												Glass	3	1.9
												Cement	3	1.9
												Telecommunications	2	1.3
												Luxury	2	1.3
												Beauty and Cosmetics	2	1.3
												Electrical and electronics	2	1.3
												Chemical	1	0.6
												Other	30	19.1
	157	1		157	1		157	1		157	1		157	1

Several approaches were used to assess the "non-response bias." The first approach consisted of comparing early and late respondents (i.e., first and second to third surveys). A one-way analysis of variance (ANOVA) found no significant differences between the early and late responses for all items. These findings support the conclusion that "non-response bias" is not a significant concern. Moreover, we checked for non-response bias by using the demographic variables size, number of employees, and average turnover. Once again, we found no significant differences between the groups. All items included in the questionnaire were measured using a seven-point Likert scale, indicating the level of agreement with a certain question (where 1 = not at all in agreement and 7 = full agreement). Therefore, because the difference between the items matters and can be directly compared, we conducted the analysis at the original items' scale. In Appendix, we describe the items together with their means and standard deviations.

3.2 Methodology

To achieve the objectives of this study, we used Partial Least Squares Path Modeling (PLS-PM); PLS-PM is a component-based estimation algorithm that aims to predict the relationships between constructs and provides their scores at the original scale. Furthermore, PLS-PM does not require any distributional assumption on the data (in contrast with a maximum likelihood covariance-based approach). Finally, PLS-PM provides less biased estimates than other approaches to structural equations modelling at sample sizes lower than 200 observations (Hazen *et al.*, 2015), while achieving the same power above 200 observations (Chin, 2010). In any case, the bootstrapping procedure available for PLS-PM allows one to mitigate such restrictions. These motivations underlie the use of PLS-PM in several business contexts, such as operations management (Peng and Lai, 2012), supply chain management (Colicev *et al.*, 2016), and digital transformation (De Giovanni and Cariola, 2020).

3.3 Model assessment

In our investigation, the constructs represent firms' traits related to their business. Hence, we model them by means of reflective scales. To assess the reflective measurement models, we must examine the internal consistency, as well as the convergent and discriminant validity. We followed the procedure explained in De Giovanni and Cariola (2020) to achieve these targets.

Some items (e.g. training programs for blockchain and last mile, lack of transparency, unattended deliveries, optimization of the logistics loads) have borderline loadings with loadings between 0.5 and 0.6. However, the results of the 5,000 resamples indicate that these loadings (and weights) are significant at 0.05 and constitute important items in terms of the content validity. According to Colicev *et al.* (2016), these items can then be retained.

Finally, we removed all items with a loading below 0.5 (i.e., "L6 – Unattended deliveries"). The elimination of the indicator "L6" from the construct logistics indicates that firms still face the issue of integrating their information with consumers. During the last mile delivery, the consumers are frequently not available at the indicated address. Therefore, firms should invest more in this direction to better integrate the logistics flow with consumer availability. Similarly, item "L9 – Optimization of logistics loads" was removed from the list of items linked to logistics. This is probably linked to the low chance that firms have to mitigate all operative challenges imposed by the warehouse management in terms of space constraints and load optimization. Therefore, the construct logistics will provide information that firms have invested in the reduction of the delivery lead time (L1), which becomes an important lever of the competitive advantage.

Logistics is composed of a set of items linked to consumers, which have been derived from the survey paper by Wudhikarn *et al.* (2018). Hereby, the authors reviewed 111 articles and identified the most important measures linked to logistics. Therefore, we focus on the most relevant, specifically: the consumers' service support for complaints and its integration with the logistics systems (L2), the information shared with consumers regarding the delivery time, invoicing, and order completeness (L3), as well as the prompt activation of ad hoc logistics practices to properly manage consumers' complaints (L4). Furthermore, logistics includes a set of achievements linked to the management of backward flows, specifically the adoption of return management procedures (L5), which require additional efforts and more atypical tasks than traditional delivery systems, the integration of forward and reverse logistics flow into one unique system (L7), as well as the optimization of the logistics network (L8) that includes all of these ingredients. Finally, the logistics strategy can never disregard the practice of logistics risks and safety (L10), which aim to preserve people's health and society at large.

Regarding the construct Economic Performance (EP), whose scale is widely used in logistics-based research (e.g. De Giovanni and Cariola, 2020), all items that we hypothesized being a part of this construct have good loadings. They include the market share (EP1), which indicates the firms' performance comparatively to the competitors, the profits (EP2), which informs on the firms' capacity to generate economic value, the ROI (EP3), which signals the firms' capacity to recover the investments through the economic outcomes, and the cost savings (EP4), highlighting the efficiency of the entire business.

Following the special issue by Verhoef *et al.* (2015), we create an ad hoc scale to capture the firms' capacity to provide omnichannel solutions. Therefore, the Omnichannel (O) construct encloses the items depicting the purchase options available to customers by the company. These include the possibility for firms to offer several options like: buying the product online and picking it up at the store (O1), receiving it at home (O2), receiving the goods anywhere else (O3), as well as picking them up from a locker (O4). Finally, we include the items linked to traditional shopping experiences "buy offline and take home" (O5) and "buy offline/home delivery" (O6), to have a comprehensive analysis of all options.

Regarding the construct Blockchain (B), being a new technology, research on scale developments is currently missing. Therefore, we propose hereby a measurement scale according to the ingredients emerged from the literature review with the purpose of exploring the practices that managers adopt when implementing this technology. The indicators relate to working with developers (B1) (e.g. IBM, Hyperledger), to implement blockchain in the enterprise environment. They also include items pertaining to the change in the standard way of managing agreements and transactions (B2) (e.g. use of smart contracts), but also the developments of tokens (B3) and the deployment of new exchanging platforms (B4) resulting from the collaboration between the SC partners. Innovations (e.g. blockchain) are required to be in line with the existing regulations (B6) and not be in conflict. Some regulations include data protection and privacy rules. These can be combined with existing digital technologies for full exploitation (B7). We have not mentioned the "B5 - New training programs" indicator, because it was removed from the blockchain construct. This indicates that companies are not yet investing in programs to help their employees and the stakeholders along the SC to familiarize themselves with this new technology.

To measure the Last Mile (LM) construct, we identified a list of possible items to use from the literature. In fact, no research has proposed a measurement scale so far to measure the firms' capacity to manage the last mile. Within the list, whose details are displayed in Appendix, some items have been removed according to the empirical results. In particular, the indicators "LM1 - Training program" and "LM8 – Lack of transparency" have been excluded. This suggests that companies have not yet been able to implement training programs coordinated with the different collaborators along the SC. They have also not established a system able to guarantee the complete transparency of the Last Mile delivery. The further removal of the items “LM9-Reinforcing tracking system” and “LM10-Investing in information system and new high tech platforms” illustrates that companies still struggle to collect and exchange product data to reduce the inefficiencies along the last mile. The exclusion of the item “LM11-Integrating third service logistics providers” indicates that it is preferable for firms to outsource the operations of the delivery phase, as it is likely too expensive.

The remaining items include some new techniques and means to transport goods (LM2). This informs on the willingness of companies to invest in improving the management of the delivery processes. Furthermore, firms undertake strategies to avoid unattended delivery problems (LM3) and to overcome problems related to urban logistics (e.g. traffic (LM4)). “LM5 – Cheap deliveries”, on the other hand, indicates the efforts made by managers to combine a high level of delivery quality with prices that are not too disadvantageous for both the consumer and the company. The Last Mile construct also highlights how companies strive to reduce high delivery costs (LM6) and how they seek to ensure that the quality of the goods delivered (LM7). The final items list allows for the detection of the cross-loadings associated with each construct, as displayed in Table 2.

The construct reliability index assesses the good internal consistency when it is higher than 0.7. In our model, all construct reliability indexes exceed this threshold (Table 3). Similarly, each items reliability should be higher than 0.7 (squared loading of 0.5), so that at least half of the item’s variance is extracted by its respective construct (Chin, 2010). Convergent validity has been evaluated by assessing the outer loadings and using the Average Variance Extracted (AVE) criterion. Table 3 illustrates that the AVE for each of our constructs is around the recommended value of 0.5 (Chin, 2010). Hence, we obtain a good convergent validity.

Finally, the discriminant validity indicates the extent to which a construct is different from the others. To achieve good discriminant validity, the AVE should be higher than the squared correlation among the constructs. In addition, the item loadings within their own constructs should be higher than the loadings on the other constructs. As displayed in Tables 2 and 3, both of these criteria are met in our model. Overall, we obtain good internal consistency and convergent and discriminant validity. Therefore, we can proceed in evaluating the structural model.

4. Results, managerial insights and theoretical contributions

4.1 Hypothesis testing

The empirical analysis of our model provides a relative Good-of-fit index of 0.807. All results are displayed in Table 4. H_1 is supported (coef. = 0.443, p-value < 0.01), highlighting that blockchain technology represents an effective technology that can be applied to successfully execute and manage omnichannel strategies. In the same way, blockchain enhances the proper management of logistics processes, as H_2 yields positive and significant support (coef. = 0.167, p-value < 0.05). H_3 is also supported (coef. = 0.273, p-value < 0.01), suggesting that investments in omnichannel are highly advantageous for a better logistics system. Our results show that the logistics are of utmost relevance to contrast and solve all obstacles that firms face during the last mile phase (coef. = 0.660, p-value < 0.01). In contrast, blockchain and omnichannel are not effective drivers to solve the last mile issue. In fact, neither H_5, which describes the impact of omnichannel on last mile management (coef. = 0.040, p-value > 0.1), nor H_6, which describes the impact of blockchain on last mile (coef. = 0.019, p-value > 0.1), are supported.

The last part of our research body considers the influence of our model on economic performance. H_7 is not validated (coef. = −0.046, p-value > 0.1), highlighting that there is no

Items	Constructs Omni-channel	Last mile	Logistics	Economic Performance	Blockchain
Buy online/pick up in-store	0.785				
Buy online/home delivery	0.867				
Buy online/delivery in other places	0.830				
Buy online/delivery in a locker	0.506				
Buy offline and take home	0.654				
Buy offline/home delivery	0.617				
Changing the transportation modes		0.506			
Rescheduling unattended deliveries		0.554			
Reengineering the urban logistics systems		0.739			
Promoting cheap deliveries		0.708			
Reducing the delivery cost		0.791			
Increasing the quality of the delivered goods		0.753			
Delivery time			0.708		
Customers queries and or complaints			0.727		
Information sharing with consumers			0.746		
Post sale services			0.793		
Return management procedures			0.732		
Integration of forward and reverse logistics flows			0.620		
Optimization of the logistics network			0.701		
Logistics risks and safety			0.586		
Market share				0.780	
Profits				0.768	
ROI				0.827	
Costs savings				0.753	
Consulting developers					0.819
Modifying the management of contracts and transactions					0.787
Tokens					0.668
New platforms					0.829
Aligning the technology requirement with the regulations					0.793
Integrating blockchain technologies with other digital technologies					0.810

Table 2.
Summary of the cross-loadings

Index of composite reliability	Average Variance Extracted (AVE)	Construct	*B*	LM	*O*	*L*	EP
0.887	0.618	*Blockchain (B)*	1.000				
0.770	0.467	*Last Mile (LM)*	0.052	1.000			
0.801	0.486	*Omnichannel (O)*	0.197	0.077	1.000		
0.853	0.496	*Logistics (L)*	0.083	0.462	0.121	1.000	
0.789	0.612	*Economic Performance (EP)*	0.052	0.364	0.048	0.449	1.000

Table 3.
Inter-construct squared correlations and reliability measures

empirical evidence of higher economic performance when companies embrace an integrated channels approach. The same holds for the H_{10} (coef. = 0.045, p-value > 0.1), whose result thwarts the connection between blockchain technology benefits and superior economic

Research Hypothesis	Direct effect	Indirect effect
H_1: The adoption of blockchain technology has a positive impact on both the implementation and the management of an omnichannel strategy	0.443***	–
H_2: The adoption of blockchain technology has a positive impact on both the implementation and the management of a logistics strategy	0.167**	0.121**
H_3: A successful omnichannel has a positive impact on both the implementation and the management of a logistics strategy	0.273***	–
H_4: A successful logistics strategy has a positive impact on both the implementation and the management of last mile delivery solutions	0.660***	–
H_5: A successful omnichannel has a positive impact on both the implementation and the management of last mile delivery solutions	0.040	0.180***
H_6: The adoption of blockchain technology has a positive impact on both the implementation and the management of last mile delivery solutions	0.019	0.280***
H_7: A successful omnichannel has a positive impact on the economic performance	−0.046	0.994***
H_8: A successful logistics strategy has a positive impact on the economic performance	0.485***	0.182***
H_9: A successful management of the last mile has a positive impact on the economic performance	0.277***	–
H_{10}: The adoption of blockchain technology has a positive impact on the economic performance	0.045	0.183***

Note(s): ***p = value < 0.01; **p = value < 0.05; *p = value < 0.1; for indirect: ***t-value>2.58, **t-value>1.96

Table 4. Results of the research hypotheses

performance. In contrast, H_8 (coef. = 0.485, p-value < 0.01) and H_9 (coef. = 0.277, p-value <0.01) are both supported; therefore, investing in logistics and in last mile management significantly increases economic performance.

Finally, we find that investments in blockchain have an indirect positive effect on both logistics (coef. = 0.121, t-value > 2.58) and last mile (coef. = 0.208, t-value > 2.58). Similarly, investments in omnichannel have a statistically significant effect on last mile management (coef. = 0.180, t-value > 2.58). These results inform that blockchain and omnichannel allow firms to solve the last mile issue as a second-tier target. Blockchain (coef. = 0.182, t-value > 1.96), logistics (coef. = 0.182, t-value > 2.58) and omnichannel (coef. = 0.194, t-value > 2.58) also have an indirect positive effect on economic performance.

4.2 Discussion and managerial insights

The empirical results allow us to provide managerial prescriptions and directions regarding the use of blockchain, omnichannel and logistics to improve last mile management and positively impact performance. The existence of a statistically significant relationship between blockchain and omnichannel provides an empirical contribution to the literature, which is currently most likely based on either specific case studies (e.g. Karmath, 2018) or theoretical research (e.g. Choi, 2019). This opens up new and challenging scenarios for managers. The transaction to an omnichannel approach requires considerable efforts in planning the simultaneous and homogeneous management of several channels. Achieving this result is frequently hindered, especially when firms operate in an extensive and fragmented supply chain composed by many players on multiple tiers. By using the blockchain system, managers can promote a reliable, verified and unalterable flow of data and information, triggering better communication and coordination between the SC parties. Therefore, blockchain enables to overcome the vision of channels as individual silos and helps companies exploit the synergies emerging by establishing interconnections between each channel. These advantages are also extended to the end-consumers. Through blockchain, managers can monitor the journey of the product along the SC, acting quickly and directly upstream, whenever problems or inefficiencies arise, and preserving consumers from potential risks. The improved product traceability benefits customers who can easily obtain information about the characteristics and provenance of, for example, the raw materials. Hence, blockchain yields an efficient and effective response to omnichannel customer expectations.

Our findings show that the positive impact of blockchain technology also extends to logistics strategies. Investing in the creation of a distributed digital ledger-based platform eliminates the frequent errors that occur in handling logistics processes (e.g. loss of documentation, loss of goods), by recording all steps of the logistics process and verifying the related performance. Therefore, our findings contrast with the ones by Francisco and Swanson (2018), which highlight skepticism about adopting blockchain to improve logistical performance and its implementation. Furthermore, we demonstrate that any time firms evaluate the implementation of an omnichannel strategy, they should rethink and redesign the entire logistics system and the related targets. From an omnichannel perspective, managers are asked to integrate all channels and manage them by applying a unique logistics strategy, which turns out to be improved and more effective. Therefore, our results are in line with the studies that highlight the positive link between omnichannel and logistics (e.g. Brynjolfsson *et al.* (2013), Hübner *et al.* (2016), Weiland (2016)), advising firms to reengineer the logistics strategy when integrating omnichannel options. We contribute to this field by developing an empirical and generalizable result.

One of the salient points of our research is to examine the impact of blockchain on last mile. Accordingly, we tested the influence of blockchain on last mile by evaluating the support given by both logistics and omnichannel. Our findings suggest that last mile inefficiencies can be significantly mitigated by investing in logistics. Last mile can be performed efficiently when firms have flexible logistics, systems to avoid urban constraints, optimal location and movements around the distribution centers, as well as suitable supporting infrastructure. Accordingly, our findings contrast with the literature that sponsors new technologies and practices to manage the last time, like crowdsourcing logistics (Wang *et al.*, 2016), new delivery points (MacCarthy *et al.*, 2019), and the usage of drones (Deng *et al.*, 2020). Hence, the last mile can be better managed by using conventional practices and options. This statement remains valid also when we investigate the omnichannel as an effective driver for overcoming the negative effects of last mile. This suggests that consumers seek to receive the products directly at home, while companies seem to not be fully prepared to effectively deal with the related complex system, generating last mile issues. Similarly, blockchain is not sufficient enough to face the challenges that firms experience when managing last mile, although the technology allows for a real tracking and verification system, along with incentives generated by smart contracts.

While the previous results hold true for the direct relationship between blockchain and last mile, the indirect effect yields the opposite results. In fact, blockchain has an indirect influence on last mile through exploiting the positive effects of the logistics system. Therefore, firms should expect that blockchain improves the last mile as a second order factor to be achieved after improving the logistics system. The latter result implies that firms should focus on the use of blockchain for logistics purposes; this will improve the last mile at the same time. The same logic applies for omnichannel. Firms can improve the last mile through omnichannel indirectly through the positive effect of logistics. Hence, omnichannel strategies should aim at improving the logistics systems to achieve better last mile as a counter effect.

Finally, our research reinforces the idea that, contrary to omnichannel and blockchain, effective logistics and efficient last mile management are essential contributors to achieve superior economic performance. Firms can expect immediate improvements of their economic performance by having a successful logistics system, as well as by performing the last mile effectively. In contrast, blockchain and omnichannel supply an indirect contribution to the economic performance, most likely through logistics, which is a suitable driver. This is a very important result in the literature, which presents blockchain as a digital technology for improving the firms' performance. Such a finding has been documented by using case studies (e.g. Karmath, 2018), empirical analysis (e.g. Ko *et al.* (2018)) and theoretical work (e.g. De Giovanni (2019a, 2020)). Our results contrast with these findings of the literature and demonstrate that the implementation of blockchain is a necessary but not sufficient condition to improve the economic performance; in fact, blockchain should give a contribution to a specific practice or function (e.g. in this research, logistics management and omnichannel) to expect a contribution in terms of economic outcomes.

Therefore, we can suggest the following investment path to firms that seek to improve the economic performance. Firstly, firms should reinforce their logistics systems to improve both the last mile and the economic performance. Hence, they can invest in omnichannel to improve the logistics and get better last mile and economic performance as a second order target. Finally, investments in blockchain can grant further improvements for logistics and omnichannel; they can also provide additional indirect benefits for last mile and economic performance.

4.3 Theoretical contributions

This study proposes a conceptual framework in which blockchain technology supports both logistics management and omnichannel in improving the last mile delivery along with the firms' economic performance. Within this framework, the study proposes two types of contributions. The first contribution is purely methodological and consists of the measurement scales developed for some of the constructs. Specifically, we developed ad hoc scales for capturing the firms' capability in implementing and managing blockchain technology, omnichannel strategies and last mile delivery. To our knowledge, the literature misses scales for these constructs; hence, future studies can build on them for further developments in these fields.

The second contribution of this study is definitely theoretical and links to the advantages that blockchain exerts in the area of logistics. We need to differentiate between connected and non-connected logistics systems. The connected logistics are all systems connected to the firms' information systems (IS); therefore, the logistics strategy *per se* as well as the omnichannel options are managed through the firms' IS, resulting then connected. Differently, the non-connected systems are not managed by the firms' IS directly and, consequently, some information and details can be lost. Since the last mile is most likely managed in outsourcing, it represents a non-connected logistics system. This difference allows us to highlight the theoretical developments of this study, according to which blockchain is a considerable booster for both logistics management and omnichannel, that is, for the connected systems. Therefore, blockchain technology contributes to increase and reinforce the firms' capabilities to implement and manage logistics and omnichannel. However, the amplitude of these effects is considerably different and turns out to be almost three times higher for omnichannel than for logistics management. In fact, given the needs to integrate several and heterogeneous selling options, omnichannel is clearly more difficult and subject to possible exceptions that create distortions and unwanted challenges. Interestingly, the higher the distortions of a certain logistics system, the higher the benefits that blockchain grants.

In terms of non-connected logistics systems, which take the form of last-time delivery in this research, the blockchain turns out to be definitely ineffective as a first-order target. That is, if the firms seek to invest in a digital technology to rapidly improve the last mile management, the blockchain technology is not the best option. Although its increasing popularity, the current state of the technology and the integration with in-bound, out-bound, software, hardware, and human oracles make the blockchain ineffective in the management of the last mile. This process, in fact, implies a disconnection from the firms' remote-control systems and leave the smart contracts without the needed inputs to activate the smart clauses. When (in the future) the eco-system will be able to integrate the oracles with the blockchain system, the last mile will be solved through this technology.

When turning the page to the analysis of the economic performance, we observe that the blockchain is not a good option when firms seek to rapidly increase the economic outcomes. The translation of blockchain investments into economic performance requires some time and, consequently, cannot be a first-order target for firms. Several challenges occur in this process such as: the management of new forms of transactions, the possible shift to the use of cryptocurrencies, the engineering of contracts and agreements followed by the supply chain redesign, the acquisition of a systematic commitment and a diffused legitimacy, the time for consumers to understand and use the value of information recorded in the blockchain. Therefore, as for the last mile, blockchain does not exert an immediate advantage.

However, blockchain grants an improvement to both the last mile management and the economic outcomes as a second-order target, which is obtained through the improvements on logistics and omnichannel that blockchain guarantees. In this sense, logistics and omnichannel become the fundamental drivers through which blockchain translates into a real success by ensuring economic feasibility and operational improvements of the last mile management. Finally, the blockchain ensures a high transparency and visibility over all omnichannel options, which translate into an economically fruitful second-order target opportunity.

5. Conclusions

This paper investigates the effect that blockchain has on businesses by analyzing its implications for omnichannel and logistics, as well as in terms of last mile and performance. In principle, all these business dimensions can be positively influenced by blockchain. The latter allows firms to better organize and integrate the channels and offer a greater seamless omnichannel experience to consumers. In addition, blockchain tracks, verifies, and records all steps of the logistics process, inducing operators and firms to behave as defined in the smart contracts to obtain the related rewards. These implications supply incentives to solve the last mile issues, which is better observed through blockchain, as well as to obtain positive economic benefits by reducing errors and waste, create incentive-based systems, and monitor SC visibility. We develop several research hypotheses and test them using a sample of 157 firms.

Our findings show that blockchain alone is not sufficient for improving the last mile and granting superior economic performance. In fact, the technology only becomes highly effective when it complements the existing technologies used to manage the entire logistics systems and integrate the omnichannel solutions. This confirms that blockchain is a general-purpose technology whose use can upgrade the value of firm businesses and actions (De Giovanni, 2020). Blockchain is an effective driver to improve the omnichannel strategy, whose integration requires a technology that verifies, records and tracks all actions and practices adopted over the connections among multiple channels.

Neither blockchain, nor omnichannel, are effective levers to improve last mile and economic performance without the powerful effect of logistics. Hence, firms should focus their efforts on an effective logistics system to solve last mile issues and achieve high economic outcomes. The use of blockchain, alongside an omnichannel strategy, can boost the positive effects of logistics. Neither can provide significant benefits when adopted alone, that is, without the support of a strong and effective logistics system.

This study is not free of limitations, which are listed hereafter to inspire future research. This research focuses on blockchain, omnichannel and logistics to improve both last mile and economic performance. Other business ingredients can be considered in future work, such as the use of Industry 4.0 technologies, the implementation of circular economy programs, or the interactions with consumers. It would be interesting to dynamically observe the effects of blockchain technology by looking at the impact on the performance and last mile over time. Other performance dimensions can be considered. These include environmental, operational, social, or supply chain performance. Finally, it would be interesting to check both the substitution and complementary effects between blockchain technologies and ISO certifications.

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Appendix

Construct	Items	Question	Mean	Standard deviation
Blockchain (B)		*In the last two years, our companies invested in blockchain by*		
	B1	Consulting developers	4.924	1.573
	B2	Modifying the management of contracts and transactions	4.393	1.523
	B3	Developing tokens	4.305	1.519
	B4	Developing new platforms	4.796	1.623
	B5	Initiating new training programs[a]	–	–
	B6	Aligning the technology requirement with the regulations	4.870	1.558
	B7	Integrating blockchain technologies with other digital technologies	4.807	1.718
Omnichannel (O)		*In the last two years, our company invested in the following omnichannel solutions*		
	O1	Buy online/pick up in-store	5.014	1.702
	O2	Buy online/home delivery	5.352	1.681
	O3	Buy online/delivery in other places	5.141	1.710
	O4	Buy online/delivery in a locker	4.553	1.745
	O5	Buy offline and take home	5.222	1.715
	O6	Buy offline/home delivery	4.681	1.805
Logistics (L)		*In the past last years, our company has successfully managed the following logistics challenges*		
	L1	Delivery time	4.820	1.754
	L2	Customers queries and or complaints	4.734	1.653
	L3	Information sharing with consumers	4.721	1.774
	L4	Post-sale services	4.337	2.085
	L5	Return management procedures	4.517	1.543
	L6	Unattended deliveries.1[a]	–	–
	L7	Integration of forward and reverse logistics flows	4.433	1.492
	L8	Optimization of the logistics network	4.974	1.523
	L9	Optimization of the logistics loads[a]	–	–
	L10	Logistics risks and safety	4.810	1.556
Last Mile (LM)		*In the last two years, our company has managed the last mile by*		
	LM1	Training programs[a]	–	–
	LM2	Changing the transportation modes	4.338	1.521
	LM3	Rescheduling unattended deliveries	3.874	1.617
	LM4	Reengineering the urban logistics systems	4.555	1.557
	LM5	Promoting cheap deliveries	4.396	1.646
	LM6	Reducing the delivery cost	4.673	1.615
	LM7	Increasing the quality of the delivered goods	4.954	1.763
	LM8	Increasing transparency[a]	–	–
	LM9	Reinforcing tracking system[a]	–	–
	LM10	Investing in information system[a]	–	–
	LM11	Integrating the TSL providers[a]	–	–
Economic Performance (EP)		*In the last two years, our company has performed in terms of*		
	EP1	Market share	4.853	1.964
	EP2	Profits	4.737	1.991
	EP3	ROI	4.814	1.797
	EP4	Cost savings	4.664	1.791

Note(s): [a] Excluded from analysis

Table A1. Descriptive statistics of the selected items