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Roles of Blockchain Technology in Supply Chain Capability and Flexibility

Tejas Potnis [1], Yui-yip Lau [2,*] and Tsz Leung Yip [1]

[1] Department of Logistics and Maritime Studies, The Hong Kong Polytechnic University, Hong Kong, China
[2] Division of Business and Hospitality Management, School of Professional Education and Executive Development, The Hong Kong Polytechnic University, Hong Kong, China
* Correspondence: yuiyip.lau@cpce-polyu.edu.hk

Abstract: Blockchain technology is a major innovation that has swept through global supply chains recently. Blockchain technology has received immense attention in the supply chain industry due to its promising capabilities. This study was conducted to evaluate the potential capabilities of blockchain technology, which are highly relevant to the supply chain industry. To improve the understanding of the effect of blockchain on the supply chain, this research focuses on two crucial aspects of supply chain management, namely, supply chain capabilities and flexibility. The research procures measuring items for blockchain characteristics, supply chain capabilities, and flexibility through a questionnaire, the previous literature, and interviews conducted with industry experts. Through the use of statistical analysis, this study identifies the relationship between the above variables. The effect of blockchain on each variable is examined using a simple linear regression model. The findings disclose that blockchain technology has generated a notable impact on the supply chain capabilities and supply chain flexibility of firms. This makes blockchain technology highly essential for firms to generate a competitive advantage in the market and develop a new set of capabilities ahead of their competitors.

Keywords: blockchain technology; supply chain capabilities; supply chain flexibility

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1. Introduction

1.1. Digital Disruption and Supply Chain

The supply chain industry experiences a considerable number of innovations every year. These innovative technologies are disrupting the supply chain industry and changing how business is done from the ground up. The vast influx of technologies is given attention due to the inefficiencies in the current systems. Firms implement these new technologies to stay ahead or stay in business and increase the efficiency of processes.

With so many technologies at the disposal of a firm, it is challenging to select one without having prior experience or knowledge about it. In failing to adopt new technologies, companies face a fear of losing out on the game. Therefore, organizations have to reconsider and redefine how to organize for such digital innovations [1] and have to be more concerned about the process of adoption of new technologies [2], as "innovation is considered a source of competitive advantage and economic growth" [3]. However, when deciding to implement a particular technology into existing systems, we have to consider every factor that can influence the impact of the technology. This is mainly because not all technologies are beneficial, and some have downfalls or threats attached to them. By analyzing the technology and factors that influence its impact, we can have a clear idea or a framework that can harness the new technology in a better way to yield a sustainable competitive advantage in the market. With the introduction of new technologies, firms have to change and evolve according to the technology, which gives rise to new coordination approaches, new tasks, and new ways of organizing [1].

Prior research has been conducted in the field of information systems that focuses on the relationship between digital innovations and organization designs, such as roles, processes, teams, and other structures. Firms face a dilemma between the requirement to mechanize and formalize the current, continuing organizational designs and the necessity to adapt to changes; therefore, technical innovation induces a massive challenge for organizations [4]. Therefore, it becomes difficult for a firm to manage its existing business with old capabilities and simultaneously develop new capabilities to bring out innovation in the design [2].

Currently, most firms use outdated manual processes for inter-organizational information sharing [5]. It is common in international trade that, due to the lack of accessible information, containers stay nearly half of their journey time [6]. Such inefficiencies lead to increased costs in global supply chains. The lack of information sharing leads to unstable coordination, resulting in low transparency and a lack of trust between the supply chain partners. The lack of information sharing and security regarding information affects the supply chain operation negatively [5]. These problems point out the issues of integration that do not correctly account for the complexity of modern supply chain systems. Information exchange, coordination, and integration are interrelated abilities of a firm that are related to the supply chain capabilities and flexibility of the firm.

1.2. Blockchain Technology

Bitcoin is a virtual currency that uses public key cryptography, presented in 2008 in a paper by an author using the pseudonym Satoshi Nakamoto. Bitcoin is the first peer-to-peer networked currency and the most widely known cryptocurrency in the world. For the first time, the author proposed a system for electronic transactions without relying on a third party for trust. In 2009, it was fully adopted and fostered by the reachability of exchange markets [7]. The initial value of Bitcoin was USD 0.06 and went unnoticed by most people. However, when the value of Bitcoin rose to USD 19,000 in December 2017, its underlying technology, "blockchain", became the newest buzzword and took the world by storm [8]. This underlying technology has ever-increasing applications in every industry, including the supply chain and logistics industry. Blockchain technology has received an overwhelming amount of hype in recent years.

Blockchain technology creates a roadmap for disruptive digital innovation [9]. With the help of blockchain technology, several new opportunities have been generated in products, processes, and business models [10]. The trust-evoking and decentralized nature of blockchain are the two key characteristics to be highlighted when looking at blockchain technology [11]. We have seen an extensive array of industries disrupted by technological innovation. A similar potential can be seen in blockchain technology to create the next significant disruption. Blockchain can be used in numerous ways to create efficiencies, and, therefore, it is regarded as a ground-breaking innovation. Especially in logistics, supply chain, fintech, and banking, blockchain is a game changer [12,13].

1.3. Research Questions

There is numerous empirical research on the benefits of blockchain technology in supply chain management, although blockchain technology is currently identified as an advanced information technology tool for considerable growth in supply chain management [14]. Most of the studies conducted fall under the category of case studies, the features of blockchain, basic blockchain operations, and the determining factors that influence the adoption of blockchain in enterprises [15,16]. Kim and Shin [14] summarized the previous blockchain research studies focused on synchronization and information distribution, smart contracts and payments, data immutability, and the P2P network. The existing knowledge of the association between blockchain and supply chain management is deficient in dealing with supply chain disruptions [15]. This study fills the research gap. As such, this research focuses on the role of blockchain technology and how it will affect the supply chain capabilities of a firm. The main research questions are: (1) What are the critical characteristics

of blockchain technology? (2) What are the supply chain capabilities that are pertinent to blockchain technology? (3) What are the supply chain flexibility measures pertinent to blockchain technology? (4) Which capabilities are enhanced due to blockchain technology in supply chain management?

2. Literature Review

2.1. Information Technology in Supply Chain Management

Supply chains have received benefits such as reliable and simultaneous transfer of relevant supply chain information within firms as well as across individual firms' boundaries by deploying or diffusing information technology into their systems [17]. A firm that has an integrated information technology infrastructure can receive the benefits of consistent information and data transfer as well as functional applications amongst its partners, ensuring smooth communication flow [18].

The research on information technology in supply chains has primarily studied the role and impact of specific technologies and innovations that have made a significant impact on supply chain management by increasing firm performance. EDI, CRP, RFID, IoT, and other hardware and software innovations have unlocked the potential of the supply chain industry to a new level. Blockchain is said to be the next emerging digital technology that will change the traditional process by reinventing the way transactions are conducted [19]. Currently, it is generally supposed that it will revolutionize and disrupt the approach firms operate in the supply chain 4.0 [15]. Blockchain technology comes under the umbrella of information technology. Blockchain technology could foster the enhancement of supply chains with resilient traceability, notably in small and medium-sized enterprises in the post-COVID-19 period [16]. Robust blockchain systems may encourage safe information transfer between topographically distributed partners to improve worldwide commerce in disciplines such as trade financing, logistics operations, and tracing and monitoring shipments [20]. Kim and Shin [14] pointed out that blockchain technology fosters visibility concerning who is carrying out which actions, as well as generates valuable solutions for shipment management and real-time supplier management. Additionally, Ivanov et al. [19] and Liu et al. [16] stated that the use of blockchain technology enhances collaboration and integration among firms, improves data quality, decreases demand unpredictability, and minimizes information disruption risks. As such, firms may optimize operational performance. EDI has long been the common ground for interaction and transfer of data and information. Information technology software and resources have been embraced by the supply chain and logistics industry to optimize productivity. Consider RFID, for example. RFID has impacted supply chains in numerous different ways. Supermarkets such as Walmart and Parknshop have started replacing some staff with automated machines that can read the RFID tag and generate an invoice for it. Supply chains that work in a highly global and dynamic environment require sophisticated IT infrastructure to sustain their business model and their dominance in the markets.

2.2. The Resource-Based View (RBV) of the Firm

RBV theory has been extensively studied by researchers to evaluate the competitive advantage and efficiency of an organization's resources [21]. RBV has been used before to discern the effect of inter-organization information technology integration on supply chain performance. RBV has been thoroughly applied to theoretical and empirical examinations to study and understand the influences of information technology on competitive advantage [22].

2.2.1. A Firm's Resources

Resources that generate a competitive advantage can be tangible or intangible. It is essential in RBV theory to define the exact meaning of a resource. RBV research has listed numerous classifications and definitions in the main glossary [23]. Sometimes, the differentiation between capabilities, resources, and assets is unclear and ambiguous in

the literature [24]. Wade and Hulland [23] described resources as "assets and capabilities that are available and useful in detecting and responding to market opportunities or threats". Assets are further classified as "anything tangible or intangible that a firm can use in its processes and operations for creating, producing, and/or offering its products (goods or services) to a market" [23]. Tangible assets in a firm include information systems software and hardware, as well as intangible assets pertaining to information technology and knowledge business relationships [23]. On the other hand, capabilities are defined as "the repeatable patterns of actions in the use of assets to create, produce, and/or offer products to market" [23]. This also includes skills such as managerial or technical ability or processes, for instance, system integration or development [23]. Blockchain characteristics are considered as the organization's repetitive forms of actions in the adoption of relevant information technology-based resources. RBV theory constructs a resilient framework for investigating how and whether blockchain technology can lead a firm to achieve a competitive advantage and increase performance. This research proposes that blockchain-enabled supply chain capabilities can modify or evolve information technology-related resources into a higher value for a firm.

2.2.2. Information Technology Capabilities

Bharadwaj [22] defines information technology capabilities as "an organization's ability to mobilize and deploy Information Technology-based resources in combination or co-present with other resources and capabilities". The superior performance and competitive advantage depend on the extent of uniqueness or difference concerning competitors. Information technology capabilities have become vital for firms due to their importance in managing material and information flows more efficiently [25]. Based on RBV, information technology researchers claim that firm performance distinctions rely on uniqueness in information technology capabilities [26]. Wang et al. [27] found that information technology resources and information technology capabilities enhance the performance of a firm by providing support to its core competencies and competitive strategies. The information technology capabilities of a firm upgrade with the diffusion of new technology into the firm's information systems. The increased ability to perform the task and process leads to higher efficiencies and productivity. In this study, Information Exchange, Coordination, Activity Integration, and Responsiveness have been considered as the dimensions of information technology capability's impact on supply chain capabilities, together with a firm's ability to deploy it into the supply chain system. This research hypothesizes that these four dimensions, together with the firm's ability to tactically deploy blockchain technology, are associated with a competitive advantage and superior performance. The increased information technology capabilities due to blockchain technology lead to increased supply chain capabilities for the firm.

To implement blockchain technology, along with project management capability and organization capabilities, a firm has to identify its IT resources and capabilities. Blockchain is a new technology and its impact is less known in the supply chain industry. Therefore, it is vital to understand the most important resource and capabilities in general that firms need to consider to achieve substantial benefits in terms of competitive advantage.

3. Hypothesis Development

To understand the effect of blockchain on the supply chain, this research focuses on two crucial aspects of supply chain management. The first is supply chain capabilities, which include four dimensions: Information Exchange, Coordination, Activity Integration, and Responsiveness. Flexibility is the second aspect involved in this research for studying the influence of blockchain technology on the supply chain. Furthermore, the resource-based view theory allows us to understand how a resource can become a source of competitive advantage for a firm. The resource-based view theory is used to conclude whether a firm can achieve some competitive advantage in the market against its rivals by implementing

blockchain technology in its information system. As such, five hypotheses are provided in Figure 1.

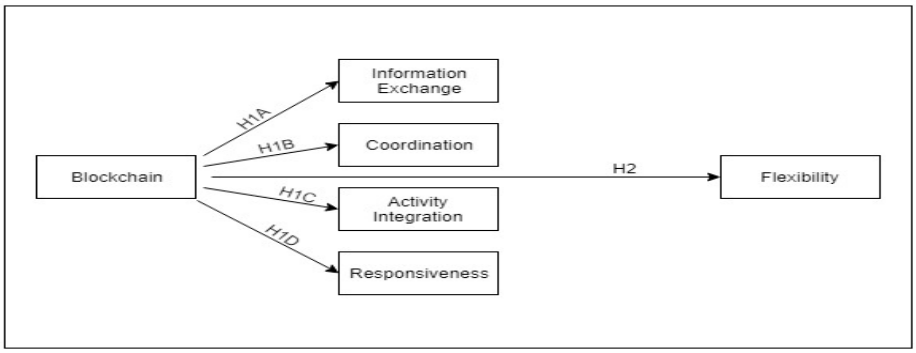

Figure 1. Hypothesis Development.

3.1. Supply Chain Capabilities

Supply chain capabilities are at a high level in the hierarchy of organizational capabilities [28,29]. Therefore, the importance of their functionality is of utmost importance to a firm. Supply chain capabilities are a direct link to the organization's performance and productivity. Firms able to enhance the capabilities of these four dimensions will improve the productivity of the supply chain, inducing a competitive advantage in the market. These supply chain capabilities are difficult to duplicate across firms and are firm-specific [28]. They are a set of dynamic organizational routines and physical assets unique to each firm. The capabilities and resources held by a firm have a direct impact on the firm's competitiveness in the market. According to the resource-based view theory, the firm manages these capabilities and resources and enables it to integrate strategies that are designed to enhance its effectiveness, which boosts financial performance [30]. It also includes communication and sharing information across the entire supply chain to facilitate activities [29]. This research proposes that using blockchain technology in the four mentioned dimensions will improve the firm's performance and will allow the firm to generate a competitive advantage in the market. Blockchain technology is an innovation in IT technology, providing an advanced IT solution for organizations.

H1: *Blockchain technology is positively related to supply chain capabilities.*

3.1.1. Information Exchange

Previous studies in the field of SCM have established a clear relationship between information exchange and supply chain performance [31]. For firms, information exchange is vital and must be accurate, secure, cheap, and fast. In an attempt to do so, firms have traditionally tried to reach out for new technologies. EDI has been the main technology for information exchange in the supply chain for a long time. Therefore, this research will focus on the impact of blockchain technology on information exchange to understand the utility of blockchain in supply chain capability.

H1a: *Blockchain technology has a positive impact on information exchange.*

3.1.2. Coordination

Coordination refers to separate entities working together for decision alignment to improve overall performance [32]. Interfirm coordination includes coordination of materials, money, manpower, and capital equipment with suppliers, distributors, manufacturers, third-party logistics providers, and retailers from order-taking to order follow-up [32,33]. An increase in coordination among partners can improve operational efficiency and reduce transaction costs, and, therefore, it is a key factor for the evaluation of a firm's supply chain capabilities [33]. Coordination of supply chain information also reduces the "bull-whip"

effect [34]. A firm's ability to coordinate can be linked to generating a competitive advantage. To maximize the potential for converting the competitive advantage into profitability, a firm must establish effective coordination within and beyond its boundaries [35].

H1b: *Blockchain technology has a positive impact on coordination.*

3.1.3. Activity Integration

The concept of integration lies at the heart of SCM philosophy [36]. Integration in the supply chain is enhanced by sharing information, knowledge, and supply chain performance in core processing activities [37]. Wu et al. [28] separated interfirm channel integration into two dimensions: interfirm technology integration and activity integration. A higher degree of supply chain integration in the supply chain can be associated with increased flexibility across supply chains. Kang and Moon [37] also showed that integration in the supply chain between partners helps firms achieve a competitive advantage in the market. There are various processes where firms can improve their working efficiency by integrating supply chain partners into their systems. This can reduce costs and time, and help firms focus on their core tasks. Previously, integration was complicated as it increased the vulnerability of cyber-attacks. Blockchain technology provides the required safety and security to the systems, and, therefore, the integration of suppliers is possible for supply chain firms.

H1c: *Blockchain technology has a positive impact on activity integration.*

3.1.4. Responsiveness

The responsiveness of supply chains to the overall efficiency and changing market requirements is an important issue for a firm. Supply chains are typically confronted with bull-whip effects, especially in the upstream supply chain. The lack of information sharing and integration between supply chain partners is the root cause of the bull-whip effect. This is mainly because the information system in supply chain management promotes immediate and precise information coordination, which decreases administrative and inventory carrying costs and increases responsiveness to dynamic market demands [38].

H1d: *Blockchain technology has a positive impact on responsiveness.*

3.2. Flexibility

Several papers have emphasized the need for flexibility in supply chain activities, especially in operation practices. Flexibility enhances a company's competitiveness, especially in overseeing the technology implementation process [39]. All the members in the supply chain, including external partners, suppliers, carriers, third-party service providers, distributors, retailers, and IT service providers, bring flexibility to the supply chain together rather than a single entity alone. This can integrate functions such as payment of commodities, distribution, and order fulfillment since they transfer via shipping, delivery, and production and as the title to them passes between various buyers. This will lead to increased flexibility for firms which will then allow finding the right markets and hidden price risks by seizing the value invested in the process along the chain at any point in time [40].

Supply chain capabilities are developed over time by a firm, and flexibility is the by-product of those capabilities. One aspect of measuring supply chain capabilities can also be supply chain flexibility. However, it is not considered in this research as a part of the study. Flexibility in supply chains represents a possible area for improvement of the firm's efficiency and a remarkable assessment tool to analyze a firm's supply chain performance and productivity [41]. Support for operational flexibility requires an advanced information system that allows timely response and agility in the dynamic market prospectus [42].

H2: *Blockchain technology has a positive impact on flexibility.*

4. Methodology

4.1. Research Design

Mixed Method

A researcher can adopt three methodologies according to the research approach and research philosophy of the research study. A 'quantitative research' study involves the collection of data (such as a questionnaire) or data analysis procedures that create or adopt numerical data, whereas 'qualitative research' involves a data collection technique (such as interviews) or data analysis procedure that produces the adoption of non-numerical data. A 'mixed method' research is a branch of multiple methods where the research selects 'quantitative' as well as 'qualitative' analytical data procedures and collection techniques [43].

In this research, the sequential mix method has been chosen, which includes qualitative data collection in the first phase and then quantitative data collection in the second phase. Using this technique gives the flexibility to collect qualitative data in the first stage and then utilize qualitative data for the quantitative data collection technique. A general flow of research design is shown in Figure 2.

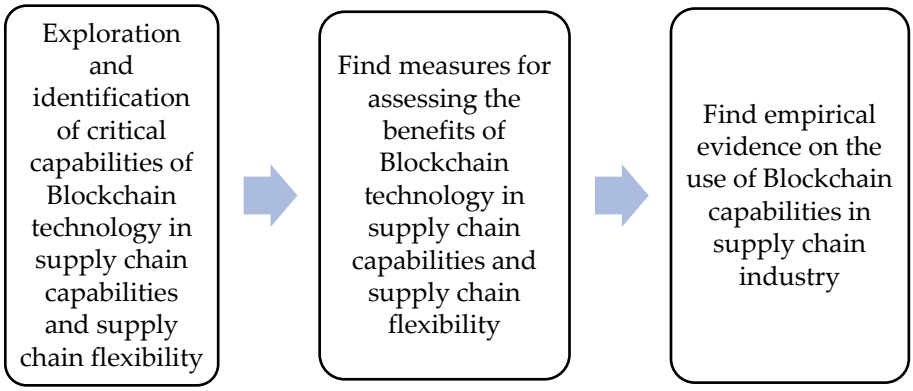

Figure 2. Flow Chart of Research Design.

Using this technique, firstly, qualitative data about blockchain characteristics were collected from four industry experts. These data were analyzed, which allowed defining 12 essential blockchain characteristics. These blockchain characteristics were then used in the quantitative technique as items for the blockchain's construct, along with supply chain capabilities and supply chain flexibility. In the next step, a questionnaire survey was used as a quantitative data collection technique to acquire numerical data for further data analysis.

Using this technique, the researcher can obtain fertile, productive, and comprehensive primary data in addition to the existing literature. This method allows the researcher to triangulate the findings from the qualitative method. Since the literature was inadequate for constructing the dimension for blockchain characteristics in this study, it was decided to use a qualitative approach. Furthermore, the quantitative methods followed the qualitative approach, allowing the researcher to test the hypotheses and gain the perspective of industry personnel regarding blockchain technology.

4.2. Interviews

4.2.1. Interviewee Profile

In the first phase, interviews regarding blockchain were conducted. The next step was to evaluate the industry of the interviewees. To make the interviews more relevant, blockchain experts working for supply chain, logistics, and shipping companies were given the first preference. Blockchain engineers or blockchain architects working for a firm that has an in-house blockchain implementation department or working for a start-up business that is based on the supply chain industry were selected.

To identify experts in the supply chain industry who possess knowledge about blockchain technology, the search focused on supply chain start-ups and supply chain companies that have embraced blockchain technology, either full-fledged or pilot tested. It was vital from the research point of view that the supply chain experts have significant knowledge and understanding of blockchain technology.

4.2.2. Criteria for Selection

For the first phase of the interview process, the selection criteria were based on the interviewee's experience and technical education background. Since blockchain technology is a relatively new technology, people generally have experience of 4 to 5 years. Therefore, it was decided to establish criteria for working experience of 3 years and more. The company's profile was also taken into consideration while selecting the interviewees, as mentioned above. In the second phase, supply chain experts with 10 or more years of working experience were selected to ensure the high accuracy of the answers. The experts interviewed in this phase had previous insights about blockchain technology and had attended conferences and seminars around the topics of blockchain and supply chain.

4.2.3. Selection and Execution Process

Using the profile and selection criteria, the search result was narrowed down to the most relevant candidates for this study. For the first phase of the interview, 13 candidates were selected, and for the second phase concerning the supply chain, 11 candidates were selected. Once the sample size was determined, the experts were contacted using emails and the LinkedIn portal. The advantage of the LinkedIn portal is that it allows the researcher to search globally. Out of 24 candidates approached, 4 candidates agreed to conduct the interview process. Due to geographical and time issues, the interviews were conducted using the Skype application and WhatsApp. The average length of the interviews was planned to be 25–30 min. However, semi-structured interviews are relatively open-ended interviews, and it is quite common to surpass the designated period. The interviews were carried out in the first and second weeks of April. The interviews were scheduled based on the interviewee's free time and convenience so that the interviewers could focus and perform the interview process thoroughly.

4.2.4. Interview Results

Once the interview process was over, the information was analyzed. Patterns were drawn from the interviews to make conclusions. Most of the questions were straightforward, with similar answers given by each respondent. In the end, a total of 12 items or characteristics were drawn from the interview process that were used in the development of a questionnaire for the quantitative study. All the interviewers emphasized the information exchange aspect of blockchain technology and how the characteristics of blockchain technology benefit it. The ability to securely store and share data was highlighted in all the interviews, which is the first item in blockchain construction. Using a blockchain system improves security in transactions. The smart contracts feature in blockchain allows two parties in the supply chain to secure a contract by using a third party to invoke trust in the transaction. Blockchain technology can integrate multiple sources, which increases business process standardization. Visibility and transparency in transactions are other key features that have a positive impact on supply chain functions. Two of the interviews explained the types of blockchain technology and how private types of blockchain can increase the speed of transactions. Utilizing the smart contract option and the digital nature of blockchain technology, every respondent agreed that the paperwork process could be reduced to a substantially low level. The decentralized nature of blockchain is resistant to cyber-attack, as each node in the system has a copy of the ledger. This allows firms to access the data and all the information required for day-to-day processes.

4.3. Questionnaire Survey

4.3.1. Questionnaire Development

The theoretical framework mentioned is the basis for the development of the questionnaire used in this research study. The questionnaire contained four sections. The first section was related to demographic information about the country, position, and industry. These three questions were compulsory for the respondent to fill in. This section also had questions concerning name, email ID, and company name, but it was not compulsory, and the respondent could choose not the answer them. The second section contained questions on blockchain characteristics, which were extracted from the interview process. The third section was divided into the following subsections: Information Exchange, Coordination, Activity Integration, and Responsiveness. The last section was concerned with flexibility in supply chain management. Research questions were measured on a five-point Likert-type scale, anchored on "1 = Strongly disagree", "2 = Disagree", "3 = Neutral", "4 = Agree", "5 = Strongly Agree", based on their opinions on particular items and questions. Google Forms was used as a tool for conducting the survey. There were two main reasons for using Google Forms instead of other means. The first is that there are no charges for using the service, and the second is that it allows the user to download surveys in an Excel file. Along with these, ease of handling was also an important aspect of its selection.

The first research questions, items IT1 to IT6, CO1 to CO6, AI1 to AI6, and RE1 to RE6, cover four dimensions. They contain the essential items related to supply chain capabilities as well as the possible effect of blockchain technology on them. These questions are the measure of a firm's supply chain capabilities after the implementation of blockchain technology for supply chain communication systems. Items FLEX1 to FLEX6 cover the second research question about supply chain flexibility in Section 3. These items are the result of the implementation of blockchain technology.

4.3.2. Questionnaire Pilot Test

Initially, the questionnaire comprised 77 questions in total, including a firm's project management capabilities, organizational capabilities, and IT capabilities. This section was related to blockchain project implementation. The questionnaire was focused on the capabilities of a firm that could influence the successful adoption of blockchain technology.

The pilot test was carried out with 15 practitioners in the area with a convenience sample, 10 from MSc part-time students at the Hong Kong Polytechnic University who were full-time practitioners in the discipline of supply chain and logistics, and another 5 were senior executives within supply chain functions. The respondents were required to show on a five-point scale the degree to which they agreed with the items. During the process of the pilot test, it was clear from the feedback that the questionnaire was too lengthy and could not be finished within 15–20 min. The feedback was common to almost every respondent, and they emphasized the long period and the high number of questions included. The pilot test was conducted between 16 April 2019 and 21 April 2019.

4.3.3. Revised Questionnaire

To collect consistent and accurate data, the questionnaire used in this research was revised after the pilot test. The number of items or questions in the questionnaire was reduced, and three constructs from Section 2 that dealt with a firm's project management capabilities, organizational capabilities, and IT capabilities were removed from the study and questionnaire. The main reasons were to reduce the scope of the study, focus on the supply chain capabilities and flexibility aspect, and reduce the time taken to complete the survey.

This led to the removal of 35 items from the questionnaire. The remaining questionnaire was then divided into three parts with a total of 42 items, with 24 items for supply chain capability construction, 6 for supply chain flexibility, and 12 for blockchain characteristics.

4.3.4. Sample Method—Quantitative

A large-scale survey was carried out after the creation of the new questionnaire. To target the right people from specific organizations and industries, Google and LinkedIn were used. In this study, the IT and supply chain industries were the core of the research. Therefore, it was important to find people who know blockchain technology and the supply chain industry. The first step was to identify the people and organizations that might have such staff using LinkedIn and Google. The shipping industry and logistics industry are segments of supply chain management, and the performance of any supply chain highly depends on these two industries, especially in global markets; hence, they are included as a subset of the supply chain industry. Therefore, organizations operating in information technology, supply chain management, logistics, and shipping were targeted.

The target respondents were senior management, supervisors, and engineers from these four industries. Top-level management was targeted due to their knowledge of operations and strategic management of the respective industry. Supervisors were targeted because they have more experience interacting with the new technology and have hands-on experience in process work. Engineers were targeted based on their ability to use technology and advanced IT-related knowledge.

The revised study questionnaire was posted to the selected respondents through the LinkedIn website. Each person was invited to participate in this research study via a tailor-made cover letter, along with the link to the survey. To boost the response rate and motivate the survey respondents to provide precise feedback, every possible respondent was guaranteed a copy of the survey result and this study. A total of 379 questionnaires were sent out.

The surveys were conducted between the 24 April 2019 and the 13 May 2019. The overall process took 21 days, i.e., 3 weeks, to complete. Each nonrespondent was reinvited to complete the survey after a gap of 7 days (i.e., 1 week). Out of the total usable responses, 64 responses were received after the initial request, and 36 responses were received after the follow-up emails.

The most commonly used method of non-response bias analysis is an independent *t*-test to analyze the difference between early and late respondents. This is a comparison between the mean value of the two groups [44]. A *t*-test was conducted to investigate any difference in all scale items between the two groups in this study. For all the constructs, the *p*-value is below 0.05. This shows no significant difference between the two groups, and it can be concluded that the difference is below the level of 5% for all constructs.

4.3.5. Justification of Data Analysis Method

In this research, two types of statistical analysis techniques were used. The first was Pearson's correlation test, which allows the researcher to establish and find the relationship between variables. The next step was carried out using a simple linear regression model. Linear regression is highly useful for evaluating the cause-and-effect relationship between variables. Through regression, the impact of an independent variable can be predicted on a dependent variable. This allowed measuring the impact of blockchain variables on other variables. This research does not include structural equation modeling, as the sample size is relatively small. The sample size plays an important role in obtaining an accurate result in SEM. Therefore, as an alternative to SEM, the regression model was used to measure the association between the variables. The regression model can prove statistical significance even when the sample size is relatively small.

4.3.6. Reliability Test

In this study, Cronbach's alpha was adopted to evaluate the reliability of the technique used for conducting surveys. The coefficient varies from 0 to 1; a value of 0.6 or less commonly shows poor internal consistency reliability. Typically, values over 0.70 are sufficient. However, many researchers identify 0.60 as a realistic cut-off standard [45]. The item–total correlation test was used to check the inconsistent items and remove them for

the analysis step. This allows for finding the items in the group that are not measuring the same construct. Any item with an item–total correlation coefficient below 0.2 must be deleted. The Statistical Package for Social Science (SPSS) version 21 was used to analyze the useable data collected from the respondents of this study.

5. Data Analysis

5.1. Descriptive Analysis

5.1.1. Response Rate and Data Cleaning

The data collection via surveys resulted in 112 responses out of 379 sent invitations, with a response rate of 29.55%. These data were cleaned and tested for reliability. The correct measure was selected, and several steps were taken to select accurate data for conducting the analysis. There are three main problems with questionnaire surveys, missing values, straight-line responses, and multiple choices. Therefore, we must carefully look for possible solutions to overcome these problems. In the end, 100 responses remained for data analysis. The removed responses accumulated to 26.38% of the total sent invitations. The number of responses was influenced by the fact that blockchain technology is a new concept in supply chains and other businesses. Thus, the survey was directed to professionals who possess knowledge about and have a particular interest in supply chain and blockchain technology. Since the number of companies embracing blockchain technology is relatively low in the supply chain area, the complexity of acquiring the right response was dealt with by personally surveying the opinion of the responder. Respondents came from various organizational levels and backgrounds, which ensures good representation across the different supply chain management domains and blockchain technology within the survey sample.

5.1.2. Respondent Groups

Participants were requested to provide demographic information on their country, position, company, and industry. The section for demographic information was optional; therefore, not all the respondents completed it. Out of 100 respondents, 34 were from the supply chain industry, followed by the logistics industry, with 22 respondents. An additional 20 respondents were from the technology industry with in-depth knowledge of blockchain technology, and 17 respondents were from the shipping industry. The other category, with 7 respondents, included trainers, advisors, and speakers from all the above categories.

Out of 100 respondents, 38 belonged to senior management, comprising department heads, CEOs, CIOs, Directors, and senior managers. Another 18 respondents were senior supervisors, which includes senior employees, such as specialists, consultants, and analysts. There were 20 supervisors, including coordinators, junior consultants, and executives. Another 12 respondents were engineers, developers, and architects who have experience with IT tools, especially blockchain technology. The remaining 12 respondents were categorized into other sections.

The surveys were sent out to people from 18 countries based on their skills and knowledge regarding the research study topic. Responses were received from 14 different countries. The five countries with the most responses were India, Hong Kong, the USA, Mainland China, and Singapore, with 47, 20, 13, 6, and 3, respectively. Two responses were received from South Africa, Australia, and the UK. New Zealand, Malaysia, Serbia, UAE, and Germany each had a single respondent.

This discussion gives a general overview of the respondents and their backgrounds. The reason for collecting surveys from different backgrounds and locations was to understand the perception of the blockchain technology world with professionals in different industries that together compromise the supply chain industry or have a notable influence on various supply chain processes.

5.2. Descriptive Analysis of Blockchain Characteristics

The only independent variable in this study is blockchain technology, and 12 essential elements of blockchain technology were extracted from four interviews with blockchain experts. The mean, standard deviation, and variance values are mentioned in the Table below. The item with the highest mean value was "BC1—Blockchain is a highly safe way to store and share information", and the lowest score was achieved by "BC12—Blockchain has a positive impact on business process standardization". The highest mean value is 4.68, and the lowest is 3.16, which is slightly above the value of 3, which resembles a neutral perception of the question. Cronbach's alpha is the average of all the potential split-half coefficients arising from various methods of splitting the scale items. For the blockchain section, Cronbach's alpha is 0.771, which is above the acceptable level of 0.7, as discussed above. The statistics for blockchain characteristics are given in Table 1.

Table 1. Blockchain Characteristics Item—Descriptive Statistics.

	Mean	Std. Deviation	Variance	CITC	Cronbach's Alpha
BC1: Blockchain is a highly safe way to store and share information	4.68	0.46648	0.218	0.512	0.771
BC 2: Data stored in blockchain is secured, tamper-proof, and cannot be changed or deleted	4.47	0.59085	0.349	0.536	
BC 3: Blockchain improves transparency in transactions	4.26	0.57654	0.332	0.494	
BC 4: Blockchain enables real-time information sharing	4.21	0.58813	0.346	0.558	
BC 5: Permissioned blockchain allows firms to choose which data to share with their partners	4.20	0.6000	0.360	0.413	
BC 7: Blockchain reduces the need for paper documents	4.13	0.54139	0.293	0.464	
BC 6: Smart Contracts in blockchain evoke trust in the transaction	4.10	0.5916	0.350	0.480	
BC 8: Blockchain improves traceability	4.07	0.62056	0.385	0.292	
BC 9: Transaction can be carried out peer to a peer basis and intermediaries are no longer required	3.98	0.54736	0.300	0.397	
BC 11: Being decentralized in nature, blockchains are less vulnerable to cyber-attacks	3.96	0.54626	0.298	0.489	
BC 10: Blockchain increases the speed of transaction	3.75	0.72629	0.528	0.213	
BC 12: Blockchain has a positive impact on business process standardization	3.16	0.56071	0.314	0.214	

5.3. Descriptive Analysis of Information Exchange

Information exchange is the first dimension of supply chain capabilities and a dependent variable in this study. The questions were designed to measure the extent of the effect of blockchain on the information exchange process. This section had six questions that were most important from the firm's point of view. The highest mean value achieved was by "IE 1: Increase in information sharing with partners, up-stream and down-stream", with 4.36, followed by "IE2: Information sharing has become clear and more decentralized" and "IE5: Increase in digital documents and decrease in paper documents", both with a 4.11 mean value. The mean score of "IE 4: Information sharing has become easier than before" was 2.61, and the CITC score was below 0.2. Any value above 0.2 is considered acceptable for analysis, and for IE4, it was −0.035. Therefore, it was decided to remove this item from the analysis. The regression analysis was conducted using only five items from this section. The reliability test carried out involved all four dimensions of supply chain capabilities since they measure the same construct. A total of 24 items were used for the reliability

test of these sections. Wu et al. [28] developed a new conceptualization of supply chain capabilities consisting of four dimensions: Information Exchange, Coordination, Activity Integration, and Responsiveness. These four dimensions represent all the important activities involved in the supply chain process. Each of the dimensions reflects the firm's ability to perform cross-functional and inter-organizational activities that are essential for the proper management of supply chains [28]. Cronbach's alpha is 0.894, which is much higher than 0.7 and signifies that the items were successful in measuring the construct. The statistics for information exchange items are provided in Table 2.

Table 2. Information Exchange Item—Descriptive Statistics.

	Mean	Std. Deviation	Variance	CITC	Cronbach's Alpha
IE 1: Increase in information sharing with partners, upstream and downstream	4.36	0.68586	0.470	0.438	0.894
IE 2: Information flow has become clear and more decentralized	4.11	0.71965	0.518	0.555	
IE 5: Increase in digital documents and a decrease in paper documents	4.11	0.67668	0.458	0.643	
IE 3: Information sharing has become more standardized and organized	3.91	0.66476	0.442	0.435	
IE 6: The IT systems are more secure and safe against unauthorized access during information sharing	3.89	0.78607	0.618	0.582	
IE 4: Information sharing has become easier than before	2.61	0.69130	0.478	−0.035	

5.4. Descriptive Analysis of Coordination

Coordination is the second dimension of supply chain capabilities and the second independent variable in this study. This section had six questions regarding the firm's coordination abilities that have an effect on the firm's overall supply chain capabilities. The item with the highest mean value, 4.2, was "CO 2: The transparency in the process has processes has improved", followed by "CO 1: Coordination is more efficient between different teams than before", with a mean value of 4.17. The item with the lowest mean value was "CO 5: Partners can input data into the company's system". The CITC score for CO5 was −0.162, which is below the acceptable value of 0.2. This item was removed for regression analysis, as the mean value was below the considerable score. The total number of items used from the coordination dimension is five. The statistics for coordination items are described in Table 3.

Table 3. Coordination Items—Descriptive Statistics.

	Mean	Std. Deviation	Variance	CITC	Cronbach's Alpha
CO 2: The transparency in the processes has improved	4.20	0.74833	0.560	0.522	0.894
CO 1: Coordination is more efficient between different teams than before	4.17	0.80069	0.641	0.431	
CO 3: The transaction follow-up has become easier and faster	4.06	0.66061	0.436	0.577	
CO 4: The increasing availability of data and information has reduced the unnecessary silos	3.95	0.75333	0.568	0.424	
CO 6: Bilateral coordination has increased	3.77	0.82286	0.677	0.587	
CO 5: Partners can input data into the company's system	2.59	0.81357	0.662	−0.162	

5.5. Descriptive Analysis of Activity Integration

The third item in supply chain capability is activity integration. The item with the highest value was "AI 1: The trust factor between partners has improved", with a mean value of 4.37. All the items in this dimension received high values and were considered eligible for analysis. The lowest mean value was 3.81 for item "AI 5: The business process standardization in communication systems has increased, and interaction has become easier". The statistics for activity integration are addressed in Table 4.

Table 4. Activity Integration—Descriptive Statistics.

	Mean	Std. Deviation	Variance	CITC	Cronbach's Alpha
AI 1: The trust factor between partners has improved	4.37	0.74371	0.553	0.557	0.894
AI 2: Partners can acquire the right quality and quantity of information for their task	4.17	0.76230	0.581	0.656	
AI 6: The partners can acquire real-time data and information	4.00	0.76158	0.580	0.530	
AI 4: Manual work has reduced due to increased partner integration (ex. document upload, etc.)	4.00	0.73485	0.540	0.637	
AI 3: The number of partner integration in supply chain communication systems has increased	3.83	0.72187	0.521	0.562	
AI 5: The business process standardized in communication systems has increased, and interaction has become easier	3.81	0.78352	0.614	0.573	

5.6. Descriptive Analysis of Responsiveness

Responsiveness is the last dimension of supply chain capabilities. All the items were chosen carefully to gain a comprehensive understanding of blockchain technology's role in it. This section also had six items. "RE 5: Traceability of the products has become more efficient for customers" was the item that received the highest mean value of 4.14, followed by "RE 1: The supply chain becomes more capable of responding quickly and effectively to the changing customer and supplier needs". All the items in this dimension received significant enough values to perform analysis. There is not much significant difference between the mean values of each item in this construct. The statistics for responsiveness items are given in Table 5.

Table 5. Responsiveness Items—Descriptive Statistics.

	Mean	Std. Deviation	Variance	CITC	Cronbach's Alpha
RE 5: Traceability of products has become more efficient for customers	4.14	0.73512	0.540	0.590	0.894
RE 1: The supply chain has become more capable of responding quickly and effectively to changing customer and supplier needs	4.08	0.77045	0.594	0.442	
RE 3: Transparency has improved the decision-making process and supply chain efficiency	4.07	0.76492	0.585	0.426	
RE 4: The partners can make better forecasts and predictions due to the availability of data than before	4.06	0.73239	0.536	0.607	
RE 2: Teams can take quick and more effective action to change competitor's strategy	3.99	0.78096	0.610	0.631	
RE 6: The teams can mitigate the damages in case of any unwanted circumstances or incidents	3.93	0.81554	0.665	0.455	

5.7. Descriptive Analysis of Flexibility

Flexibility is another independent variable in this study. The question for this section was chosen from the literature review discussed above and with the help of the interviews conducted. This section has a total of 6 items that relate to the performance of the supply chain. The questions were designed to understand the perception of the industry toward blockchain technology. The item with the highest mean value of 4.26 was "FLEX 2: The attempt of fraud and input of misleading and false information can be easily and quickly tracked down in Blockchain, allowing to mitigate its impact on end consumers". The item with the lowest mean value was "FLEX 5: Blockchain technology enhances the control of management over the environment of the organization allowing to take quick decisions and adapt to the changing circumstance", with 3.95. The for the items in the flexibility domain was 0.838, which is significantly higher than the acceptable value. The statistics for flexibility items are described in Table 6.

Table 6. Flexibility Items -Descriptive Statistics.

	Mean	Std. Deviation	Variance	CITC	Cronbach's Alpha
FLEX 2: The attempt of fraud and input of misleading and false information can be easily and quickly tracked down in Blockchain, allowing to mitigate its impact on end consumers	4.26	0.76968	0.592	0.494	0.838
FLEX 1: Blockchain increases the ability to cooperatively manage the intra-organizational and inter-organizational process to achieve effective and efficient flows of products, services, information, money, and decisions	4.10	0.84261	0.710	0.631	
FLEX 6: The robust integration ability provided by Blockchain evolves the supply chain into a team instead of fragment parties, increasing the performance in terms of cost, time, and quality	4.08	0.85650	0.734	0.698	
FLEX 4: The visibility of accurate information due to blockchain integration allows suppliers and manufacturers to foresee any situation, reducing the response time, volatility, and seasonality in supply chains	4.07	0.82771	0.685	0.482	
FLEX 3: The Blockchain platform is easily accessible to partners and can be accessed through a cloud-based server without actually installing the program, making it cost and time effective for the execution of daily tasks	3.98	0.89420	0.800	0.653	
FLEX 5: Blockchain technology enhances the control of management over the environment of the organization allowing to take quick decisions and adapt to the changing circumstance	3.95	0.86458	0.748	0.725	

5.8. Correlation Analysis

The correlation between the independent variable (blockchain utilities) and dependent variables (supply chain capabilities and flexibility) was positive. The correlation between the dependent variables was also recorded as positive and significantly high. The *p*-value for all the coefficients was 0.000, making it a highly significant correlation. In supply chain research, any value of *p* below 0.05 is acceptable.

Table 7 depicts the correlation coefficient between blockchain characteristics and supply chain capabilities (Information Exchange, Coordination, Activity Integration, and Responsiveness) and flexibility. The correlation coefficient of blockchain characteristics with Information Exchange was 0.745 ($p < 0.01$). Coordination had a correlation coefficient of 0.730 ($p < 0.01$) with blockchain characteristics. Activity Integration and Responsiveness

correlated to 0.675 ($p < 0.01$) and 0.763 ($p < 0.01$), respectively, with blockchain characteristics. Responsiveness had the highest correlation coefficient with blockchain characteristics, followed by Information Exchange. The correlation coefficient of flexibility with blockchain characteristics was 0.556 ($p < 0.01$), which is relatively lower compared to other variables in the study but significant enough to establish a relationship between the variables. The whole result of the correlation analysis from SPSS is shown in Table 8.

Table 7. Correlation Matrix for Blockchain Characteristics.

		IE	CO	AI	RE	FLEX
BC	Pearson Correlation	0.745 **	0.730 **	0.675 **	0.763 **	0.556 **
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000

** Correlation is significant at the 0.01 level (2-tailed).

Table 8. Overall Correlation Matrix.

		IE	CO	AI	RE	FLEX	BC
IE	Pearson Correlation	1	0.820 **	0.842 **	0.827 **	0.638 **	0.745 **
	Sig. (2-tailed)		0.000	0.000	0.000	0.000	0.000
CO	Pearson Correlation	0.820 **	1	0.834 **	0.814 **	0.683 **	0.730 **
	Sig. (2-tailed)	0.000		0.000	0.000	0.000	0.000
AI	Pearson Correlation	0.842 **	0.834 **	1	0.844 **	0.627 **	0.675 **
	Sig. (2-tailed)	0.000	0.000		0.000	0.000	0.000
RE	Pearson Correlation	0.827 **	0.814 **	0.844 **	1	0.750 **	0.763 **
	Sig. (2-tailed)	0.000	0.000	0.000		0.000	0.000
FLEX	Pearson Correlation	0.638 **	0.683 **	0.627 **	0.750 **	1	0.556 **
	Sig. (2-tailed)	0.000	0.000	0.000	0.000		0.000
BC	Pearson Correlation	0.745 **	0.730 **	0.675 **	0.763 **	0.556 **	1
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000	

** Correlation is significant at the 0.01 level (2-tailed).

The result of Pearson's correlation test and all the correlation coefficients were satisfactory from this study's point of view. The *p*-value for all the variables was in the right criteria. Correlation helped to establish the relationship between the variables. Amongst supply chain capability, all the variables are highly correlated with each other, with a coefficient above 0.81 ($p < 0.05$). Flexibility has a high correlation coefficient with supply chain capabilities. Although the study does not analyze the cause and effect of supply chain capabilities and flexibility, it can be a topic for further research.

5.9. Regression Analysis

To test Hypotheses 1a, 1b, 1c, 1d, and 2, regression analysis was used to estimate supply chain capabilities and flexibility parameters on blockchain characteristics. Regression analysis was used to investigate the cause and effect of an independent variable on the dependent variable. Once the correlation has been established, regression analysis helps to understand the cause and effect between variables. The coefficient of regression analysis can be between 0 and 1, that is, from 0 to 100%. The value of the coefficient closer to 1, the higher the efficiency of the regression analysis.

Regression of supply chain capabilities and supply chain flexibility was conducted to support Hypothesis 1 (1a, 1b, 1c, and 1d) and Hypothesis 2. The regression analysis for supply chain capabilities was conducted in four dimensions: Information Exchange, Coordination, Activity Integration, and Responsiveness. As shown in Table 9, the model was successful with $p < 0.05$, which represents high significance in the study conducted.

Table 9. Regression Summary—Supply Chain capabilities.

Supply Chain Capabilities					
Model	**R**	**R Square**	**Adjusted R Square**	**ANOVA Sig.**	***p*-Value**
IE	0.745	0.555	0.551	0.00	0.00
CO	0.730	0.533	0.529	0.00	0.00
AI	0.675	0.456	0.45	0.00	0.00
RES	0.763	0.583	0.578	0.00	0.00

It can be concluded that Hypothesis 1 (1a, 1b, 1c, and 1d) can be supported by the data analysis, and blockchain technology has a positive effect on the firm's supply chain capabilities.

Hypothesis 2 was also supported with regression analysis with statistical significance. The summary results are given in Table 10.

Table 10. Regression Summary—Supply Chain Flexibility.

Supply Chain Flexibility					
Model	**R**	**R Square**	**Adjusted R Square**	**ANOVA Sig.**	***p*-Value**
Flex	0.556	0.309	0.302	0.000	0.000

A summary of all the results of the hypotheses is demonstrated in Table 11 and Figure 3. All the hypotheses are supported based on the finding and analysis conducted in this Section.

Table 11. Hypothesis Results.

Hypothesis	Results
Hypothesis 1: Blockchain technology is positively associated with supply chain capabilities	Supported
H1a: Blockchain technology is positively associated with information exchange	Supported
H1b: Blockchain technology is positively associated with coordination	Supported
H1c: Blockchain technology is positively associated with activity integration	Supported
H1d: Blockchain technology is positively related to responsiveness	Supported
Hypothesis 2: Blockchain technology is positively related to supply chain flexibility	Supported

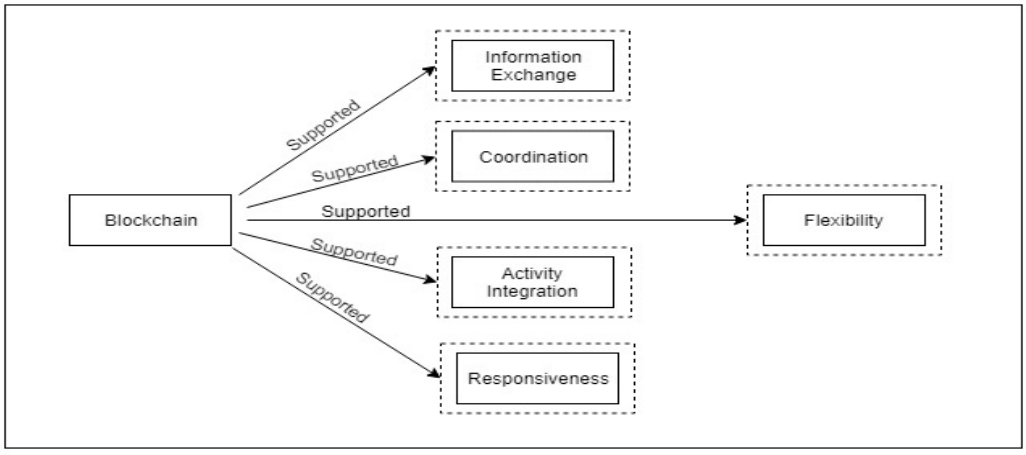

Figure 3. Summary of Hypothesis Results.

6. Conclusions

6.1. Summary

The goal of this study was to receive valuable insight into the potential benefits of blockchain technology in supply chain management. Accordingly, four main research questions were generated to answer the research study's objectives. The empirical data were gathered from survey questionnaires and interviews conducted with industry experts.

To understand how blockchain technology can affect supply chain capabilities and flexibility, a thorough literature review was conducted. The characteristics of blockchain technology concerning supply chain capabilities and supply chain flexibility were studied, followed by the development of two hypotheses concerning supply chain capabilities and supply chain flexibility. The first hypothesis relating to supply chain capabilities has four sub-hypotheses for each dimension within supply chain capabilities.

The measuring items are drawn from the literature and interviews conducted during the study. The measures include blockchain technology, supply chain capabilities (Information Exchange, Coordination, Activity Integration, and Responsiveness), and supply chain flexibility. The four main dimensions of supply chain capabilities and supply chain flexibility have six items each, which are likely to be affected by blockchain technology. The blockchain characteristics include twelve items derived from the interviews conducted. Based on the research findings, we identify that the classic supply chain model is able to deal completely with dynamic supply chain risks and ever-changing supply chain members, and hence, the importance of firms constructing a flexible supply chain is further addressed. In a time of supply chain restructuring, how to construct a flexible supply chain is a critical issue for firms in the dynamic context. Firms have been purposefully trying methods to increase supply chain flexibility and combining blockchain technology into supply chain operations [46]. Thus, most of the survey respondents perceived blockchain as a significant emerging technology in a period of Industry 4.0, which generates various possible adoptions of supply chain integration and collaboration. Further, our study proposes that the key technical characteristics of blockchain can be especially useful in complicated supply networks, notably when shown by coopetition [47].

Once the questionnaire was developed, it was distributed based on the expertise and profile of the respondents. To test the hypotheses, Pearson's correlation analysis was adopted to study the association between the variables. Then, regression analysis was adopted to evaluate the cause-and-effect relationship between the variables. Based on the findings from the analysis, the study was successfully conducted, and all the hypotheses were supported by the analysis.

The empirical finding showed that blockchain technology offers a vast domain of new capabilities that can increase efficiency in the supply chain process. Through the findings, it can be concluded that all the dimensions within the supply chain capabilities have the potential to generate more value for companies. Blockchain can also improve the flexibility aspect of supply chains. The use of blockchain technology not only has an impact on a firm's inner efficiency but also creates essential benefits for its suppliers, partners, and customers. Furthermore, blockchain technology can prove to be a sustainable solution for heavy paper in the supply chain industry. Integrating partners into the company's systems improves the trust between a firm and its partners. The improved information exchanging ability of a firm and its partners can be more than valuable in the competitive market.

The flexibility of a firm determines its sustainability in an ever-increasing competitive market. Through the blockchain supply chain, firms gain more control over their activities and have better monitoring capabilities. This allows them to respond to situations and circumstances which are beyond their control with minimal penalties in terms of cost and time—the traceability of the product helps to mitigate losses and develop a trust factor with its customers.

As per the findings of this research, it can be proposed that implementing blockchain technology in the supply chain communication system has the potential to provide a competitive advantage in the market for firms. Firms that choose to implement blockchain

technology also have a better chance of sustaining this competitive advantage in the long run. The answer to the first research question was found through the qualitative method of data collection. The critical characteristics were found through interviews with experts in the field of blockchain and supply chain technology. These characteristics were then used in the survey, along with supply chain capabilities and supply chain flexibility. Through a literature review, interviews, and events and symposiums attended by the researchers, an outline for supply chain capabilities and supply chain flexibility was derived for understanding blockchain technology's potential impact.

6.2. Theoretical and Managerial Implications

The current study contributes both to managerial and theoretical implications by associating blockchain technology with the primary purpose of improving supply chain capabilities and supply chain flexibility. The existing body of literature provides great insight into the benefits of blockchain technology in supply chain management, but there is a relatively low number of cases where the researcher has performed an empirical study. In this research, blockchain technology was proven to have a significantly positive relationship with two of the supply chain parameters.

Theoretically, this research extends the scope of academic knowledge regarding the characteristics of blockchain technology in supply chain capabilities and supply chain flexibility. This research provides separate characteristics of blockchain technology that are highly susceptible to supply chain capabilities and flexibility. The framework of four dimensions under supply chain capabilities was tested and evaluated with a focus on the role of blockchain through surveys and interviews. The framework of the flexibility aspect was derived with a focus on blockchain technology's impact. This study ranks the most important changes that can be brought about by blockchain technology in the supply chain industry. The items for measurement of the impact of this new technology were drawn for assessment and evaluation in each segment of supply chain capability and flexibility. Moreover, this research supported the literature and findings reviewed, which lacked empirical evidence.

The managerial implications mainly address the potential of blockchain technology for firms, organizations, and other global supply chain entities. This research makes two major managerial contributions to the existing literature. First, blockchain technology improves supply chain capabilities by enhancing the four dimensions within it, which are Information Exchange, Coordination, Activity Integration, and Responsiveness. It improves safety and security in information sharing. The characteristics of blockchain technology make the supply chains more transparent and increase visibility across the supply chains. Smart contracts can help firms to invoke trust in the transaction involving a third party, which reduces cost and time. The unique ability of blockchain technology to integrate partners in the information systems of a firm provides suppliers with access to more information at the right time, which leads to an increase in decision-making and planning ability. Second, blockchain technology positively affects supply chain flexibility, which is the capability to react to uncertainty in supply chains. Firms achieve more control over their supply chain without the fear of compromising the security and safety of confidential information. Traceability along the supply chain improves, which is highly valuable from the customer's perspective. Blockchain technology's ability to track and monitor the product is, so far, the most sophisticated technology out there. These capabilities can help a firm improve its internal performance and achieve a competitive advantage through means of blockchain technology. As discussed in Section 2, a firm's ability to deploy its resources successfully allows it to achieve a sustainable competitive advantage in the market. Blockchain as a resource can be highly valuable for firms, and findings suggest that it certainly provides a huge advantage to the companies that embrace it before their competitors.

The accurate implementation of blockchain fosters maritime logistics firms and port operators to minimize third-party engagement, achieve strategic advantages over key competitors, significantly decrease costs, and reduce transaction time. Blockchain flexibil-

ity and capacity in the maritime supply chain can encourage the sustainable and stable development of port enterprises, minimize waste, utilize resources, and control the budget of strategic investment. Blockchain is certainly the method of the future, and the maritime industry has started paying attention to this. Although human interaction and manual systems have typically been used in global shipping to deliver goods across geographical regions, the growing trend toward blockchain is fundamentally transforming the face of global maritime logistics and port management. Port digitalization and e-maritime logistics are emerging as a rising trend to counter rising e-business, leading to maritime logistics and port management providing higher capability, cost-savings, and efficiency.

6.3. Limitations and Further Research

There are some limitations in this research study, which should be taken into consideration when clarifying the study result.

This study highlights a relatively new emerging topic, but there are some limitations. Blockchain technology is evolving rapidly and is still in its infancy stage, and most of the companies providing solutions do not have much experience in how successful the technology is concerning the supply chain. The study is based on the perception of respondents regarding blockchain technology. Blockchain technology is a relatively new technology, and only a few companies have implemented this technology into their system. The underlying faults and traits in the technology are yet to be understood and examined. The research is based on positivism towards blockchain technology. Another limitation is related to the sample size of the surveys. Since the number of working professionals in the supply chain, logistics, and shipping who understand and have experience using blockchain technology is relatively low, the sample size was restricted. The study does not consider the difference between supply chains according to the type of industry; for example, the supply chain of a retail firm is different from an automotive firm. Retail firms have many suppliers, whereas automotive supply chains have a few dedicated suppliers. Lastly, the study did not include control variables such as organizational size, employee number, etc.

Further research can be pursued based on the limitations revealed above; one can demonstrate an almost identical study in better states to achieve better results. Improving the sample size, several investigated industries, and interviews will enable the researcher to obtain more precise conclusions and more accurate insights regarding blockchain technology and its impact on supply chain capabilities and flexibility. Moreover, in the future, there is the probability of an increasing number of companies that have harnessed blockchain technology. This will clarify the effect of blockchain in a more detailed and accurate way. Using Transaction Cost Economics theory to evaluate blockchain technology could also be an important topic for consideration. Another suggestion is developing an assessment framework for companies implementing blockchain technology into their existing system. This can include the firm's project management capabilities, organizational capabilities, and IT capabilities. The most influential characteristics can be derived from this study through the medium of empirical data collection, which will have direct implications and applications in the supply chain industry.

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