Journal of
Risk and Financial Management

MDPI

Article

Blockchain-Augmented Digital Supply Chain Management: A Way to Sustainable Business

Samir Yerpude [1], Kiran Sood [2] and Simon Grima [3,4,*]

[1] Faculty of Management, Symbiosis Centre of Research and Innovation, Symbiosis International (Deemed University), Lavale, Pune 412115, India
[2] Chitkara Business School, Chitkara University, Rajpura 140401, India
[3] Faculty of Business, Management and Economics, University of Latvia, LV-1586 Riga, Latvia
[4] Department of Insurance, Faculty of Economics Management and Accountancy, University of Malta, MSD 2080 Msida, Malta
* Correspondence: simon.grima@um.edu.mt or simon.grima@lu.lv

Abstract: The objective of this article is to assist the reader in understanding the journey from traditional Supply Chain Management to Digital Supply Chain Management. It aims to augment the concept of Digital Supply Chain Management with blockchain technology and create an extensive literature review to assist in formulating the gaps and discovering the variables that contribute towards the efficiency of a Blockchain-Based Digital Supply Chain. Moreover, this article aims to validate the impact of specified parameters resulting in customer retention and market leadership for an organization. Digital technologies such as the Internet of Things, blockchain, etc., are disrupting the traditional ways of doing business and creating value propositions for customers. Supply Chain Management is a key business process for an organization that helps them compete in the market. Organizations have seized competition not as individual brands but as supply chains. Digital Supply Chain Management is the implementation of digital technologies to capture customer data at every interaction to create customer engagement strategies. This article provides an empirical analysis of parameters influencing a Blockchain-Augmented Digital Supply Chain resulting in customer retention and market leadership and shows how, through a Blockchain-Based Digital Supply Chain, the business objective of being a customer-centric organization is assisted with the customer data generated at each interaction that is enabled.

Keywords: blockchain; supply chain; supply chain management; digital supply chain management; IoT; blockchain technology; digital technologies

Citation: Yerpude, Samir, Kiran Sood, and Simon Grima. 2023. Blockchain-Augmented Digital Supply Chain Management: A Way to Sustainable Business. *Journal of Risk and Financial Management* 16: 7. https://doi.org/10.3390/jrfm16010007

Academic Editor: Thanasis Stengos

Received: 1 December 2022
Revised: 18 December 2022
Accepted: 19 December 2022
Published: 23 December 2022

1. Introduction

Organizations rely on the efficiency of their supply chains to cater to ever-changing customer demands. Rather than differentiating themselves by brand name, they are competing by presenting themselves in the market as complete supply chain organizations. An organization's success depends on how well the different constructs of its supply chain interact with each other globally. There are different flows enabled in a supply chain, such as material flow, information flow, asset flow, capital, etc., and they are not just restricted to logistics. A supply chain tracks all the mentioned flows and manages them within the network (Eljazzar et al. 2018). Recent developments in the Information Technology domain have emphasized electronic data exchange over the internet between the different business partners in a supply chain. There are certain inadequacies observed even with some large organizations with respect to the knowledge and designing of complete information platforms that integrate with their supply chains. To cater to this requirement, such organizations work with external agencies to accelerate the implementation of a Digital Supply Chain (DSC). The automated flows include the material mentioned above, as well as information, asset, and capital flows. The production of billions of products, along with their sale, etc., is captured and stored, which assists in handling the complexity inherited by the present supply chain. A Digital Supply Chain uses trusted third parties for process and data integration. However, experts challenge the use of third-party interventions and encourage the usage of blockchain technology (Korpela et al. 2017). Blockchain is a distributed ledger technology that has revolutionized data sharing between all the relevant actors, including global partners. It simply creates a block or a stack of information in a predefined data structure that makes it feasible to store with a time stamp for each digital transaction. This enables the encoding and publishing of the information only to authorized stakeholders (Lummus et al. 2001). The advantage of implementing blockchain is that information is stored in blocks with all the relevant transaction information without any identity of the transaction party. Public Key Infrastructure (PKI) is deployed to inform the relevant stakeholders in a chain about a transaction with the smart contract concept (Korpela et al. 2017). Supply chains are the backbone of most industries and play a critical role in the longevity of an organization. The dynamics in the market are changing continuously, translating into volatility for businesses. The efficiency of a supply chain is dependent on the extent of data available. The data required include customer data at every interaction along with the performance data of the supply chain. It aids in gap assessment and defining strategies for the alignment of market demands. Supply chains have some inherent challenges, which are discussed in the following sections, that provoke the implementation of Digital Supply Chain Management. Technologies such as the Internet of Things and blockchain help in such large transformations. This article is designed to assist the reader in understanding the journey from traditional Supply Chain Management to Digital Supply Chain Management. It further augments the concept of Digital Supply Chain Management with blockchain technology. The extensive literature review assists in formulating the gaps and discovering the variables that contribute towards the efficiency of a Blockchain-Based Digital Supply Chain. The primary data was collated with the help of a structured questionnaire sent to the respondents through a google survey link. The data analysis with measurement and structural equation models is presented along with the findings and discussion. Researchers have further discussed the limitations and future research in this domain.

This article provides an empirical analysis of parameters influencing Blockchain-Augmented Digital Supply Chains resulting in customer retention and market leadership. The past few decades post Industry 4.0 coming into existence have been recording exponential growth in the implementation of Digital Technologies. The automation of customer data captured at every interaction has become a critical agenda for organizations. The Internet of Things and connected ecosystems have increased momentously, aiding the capture of essential data. Blockchain that works on the principle of distributed ledgers has transformed the lifeline of organizations, i.e., the supply chain. The researchers in this article discuss Blockchain-Augmented Digital Supply Chains with the help of a conceptual research model. The impacts of parameters, such as the business model and strategy, information platform, business process standard, and data transfer integrations, on a Blockchain-based Digital Supply Chain's efficiency are verified. Structural equation modeling is deployed to validate the impacts of the listed parameters resulting in customer retention and market leadership for an organization, elaborated on in the literature section below.

This article first introduces the subject and the context along with the list of abbreviations. Then, the theoretical foundations are discussed, including an in-depth study of Blockchain-Based Digital Supply Chains. A conceptual model is conceived, building a hypothesis for each of the identified parameters. Structural Equation Modelling is deployed to validate the model as a part of the methodology. The results are discussed with the help of different statistical measures and concluded. The research methodology is then explained to enable replication and includes an introduction and literature review of the theoretical foundations and application of such. A conceptual research module is then created on the basis of the hypotheses formulated. Following this, the data collection and sampling are determined and analyzed using the structural equation modelling statistical technique to populate the results. The results are then discussed and a section on future research directions in this domain is included.

2. Theoretical Foundations

Blockchain: Blockchain is, fundamentally, a distributed database of public/private ledgers consisting of transactional records stored as encrypted blocks in the chain. These blocks are primarily digital events shared with the blockchain's relevant stakeholders (Crosby et al. 2016). The records can be easily traced. Four differentiating traits differentiate blockchain from other technologies, i.e., decentralization, information security due to encryption, audibility, and effective execution (Baker and Steiner 2015). Researchers and managers from different industries are implementing multiple projects related to blockchain and distributed ledgers. Blockchain is proving to be a disruptive technology, finding a place in all business processes, while it initially gained prominence in the financial domain. Another domain wherein a potential is identified is Supply Chain Management. Digital technologies such as the Internet of Things are dominating supply chains.

Using sensors, RFID, barcodes, GPS tags, etc., help to identify the locations and movements of products. Real-time tracking of parts is possible. However, there is an issue observed in IoT implementation, which is of confirmed identity. Organizations wish to obtain identity information wherein IoT implementation, with the help of serialized assets, can confirm location and perform tracking. A transaction is represented by the output of every sensor in an IoT ecosystem. The system integrators mostly face issues with the millions of sensors that are working and claiming. Determining the origin of data or performing an audit of the same is usually a significantly tedious task. IoT systems are characterized by data anonymity while built on the blockchain infrastructure. Each sensor in an IoT ecosystem generates data that are communicated via a JavaScript Object Notification (JSON) with the blockchain Application Programming Interface (API) layer. The data at the blockchain infrastructure entry point are aggregated and communicated to the network post-encryption. The entirety of the blockchain nodes get updated with the data and remain the source of truth that can be verified by any user (Jayabalasamy and Koppu 2021). Blockchain implementation gives an organization the biggest advantage at dealing with the identity issue. It assists an organization with information on the supply chain actor performing an action, along with the time and location. Blockchain, when implemented in the supply chain domain, enables the measurement of key performance indicators of the different entities in a chain, even globally. We especially mention the tracking data, which, once inputted, records all transactions, and all relevant stakeholders are promptly informed. The data-sharing model induces trust in a complete supply chain, including the customer and vendors, beyond organizational boundaries. Supply chains are complex, and blockchain helps a supply chain with in-transit quality performance information (Kshetri 2018). Another unique application of blockchain is smart contracts. Blockchain enables real-time data capture along with identity and assists with tracking contract-related deliverables. Smart contracts are slowly drawing the significant attention of researchers and industrialists due to their simplicity in use (Szabo 1997). Blockchain finds an irrefutable space in modern business processes and Supply Chain Management.

Supply Chain Management: There has been a vast difference in how the markets are behaving compared to what they were a few decades ago. Customer behavior is continuously changing with global entrants. Customer demands are highly volatile, due to which business management has entered a new era of completion in which networking plays a crucial role. In a complex environment, a firm's success will depend upon its ability to integrate and create a network of business relationships (Drucker 1998; Bowersox 1997). The fundamental management of these relationships is termed Supply Chain Management. It provides organizations with the opportunity to capitalize on synergies, including global actors. SCM encapsulates total business excellence and adds a capability to carry out the activity of managing a business and relationships with other supply chain stakeholders in a new way. In the modern era, firms do not compete in the market in isolation as a brand versus brand or store versus store, but they compete as a supply chain versus a supply chain. There are eight constructs that form a part of Supply Chain Management: Customer Relationship Management, Customer Service Management, Demand Management, Order Management, Manufacturing Flow Management, Purchase or Supplier Relationship Management, New Product Development and Commercialization, and finally, Returns Management (Lambert and Cooper 2000). For an organization to function efficiently, these constructs must work seamlessly, interacting with each other. Supply Chain Management is the planning and coordination required for the movement of a product from the supplier to the customer through this interconnected network. Traditionally, these supply chain linkages were handled physically, maintaining an equilibrium between the customer demand and the supplies. With the increased scope of business, number of customers, geographical locations, and global operations, handling these activities manually became impossible (Büyüközkan and Göçer 2018). Organizations were forced to work on integration technologies and interconnected networks that communicated with each construct and produced a data communication model. Organizations need seamless integration and data sharing between the constructs so that the constructs function autonomously and are aligned with the common objective of organizations to meet customer demand in the best possible way (Fiala 2005). This became possible with the interventions of information technology and digitalization that have touched almost all aspects of supply chains (Büyüközkan and Göçer 2018).

Digital Supply Chain Management: The main objective of a supply chain is to ensure that all the steps required to meet customer demands are taken. These steps are ensured by following the Supply Chain Operations Reference (SCOR) model (Huan et al. 2004). This helps communicate a supply chain decision throughout the organization and, externally, to the vendors and customers. Organizations need to focus on lowering costs and optimizing production processes. To achieve these targets, management of their supply chain is very critical. Contemporary business processes are complex, with volatile customer demands and huge resource requirements. The silos that have existed between the various constructs and functions need to be broken to achieve the integration of all the different constructs. Digital Supply Chains enable this integration, uniquely connecting all the facets and breaking the silos in operations (Büyüközkan and Göçer 2018). Digital Supply Chains are enabled over the web with IT-enabled business processes. A Digital Supply Chain's inherent capabilities include using technologies that can generate data related to different transactions with the help of smart devices. These smart devices are sensors that are deployed at appropriate positions to capture the data about the change of state that takes place. These data are then transmitted over the internet and collated in a central repository.

The technology that aids this complete framework and assists the data collection is termed the Internet of Things (Lou et al. 2011). A Digital Supply Chain is, fundamentally, a platform for capturing and utilizing real-time data for agile decision making in different processes. In view of the variety of products, shortened product lifecycles, demand variability, and global competition, it is extremely critical that demand data are transmitted through a supply chain in the fastest possible way (Ambe 2009; Lee et al. 1997). The internet at present is the fastest medium available for the transfer of data. Digital technologies such as the Internet of Things are being implemented to transmit demand data collated through a supply chain until the suppliers meet the need (Atzori et al. 2010). Supply chain sizes are increasing daily with growing complexity. There is an amplified need for tracking and coordination. Digital Supply Chains inherently offer improved flexibility and augmented efficiency. Continuous disruptions are happening in the digital space and Supply Chain Management, provoking a stronger collaboration between the two. There are continuous pressures due to global players. There are some other implicit benefits that the Digital Supply Chain inherits, such as:

a. Speed: This aspect is the prime driver and foundation of a Digital Supply Chain. The enabler for speed proves to be stock information that should be available to all supply chain actors. Lead times are shortened, and an organization can quickly supply against the demand.

b. Flexibility: Market scenarios constantly evolve, and organizations must exhibit agility to cater to customer demands. Supply chains do not answer the question of how products were delivered but respond to how problems were eradicated so that products could be delivered. Digital Supply Chains offer flexibility in operations to meet changing market scenarios with agility.

c. Global businesses: In the past decade, the internet has been pervasive and has connected the world. Globalization has helped global players conduct business worldwide and has simultaneously enabled local manufacturers to sell abroad. This has made Digital Supply Chains global, whereby even sellers can react at the local level.

d. Real-time inventory: Warehouse management is strengthened by real-time data. It ensures that inventory levels are always optimum. Stock levels are continuously monitored with the help of sensors in a Digital Supply Chain. Consumer behavior is changing drastically. They can order anything anytime, but organizations cannot maintain inventory at every location and for all product varieties. Real-time data enable quick and fact-based or informed decisions. Real-time data also ensure that systems become capable of pre-empting and forecasting issues before they are encountered in the systems (Bechtold et al. 2014).

e. Visibility: A Digital Supply Chain with a transparency of data flow to all the relevant stakeholders in the chain enables the visibility of orders. This capability enables the chain actors to be prepared for all disruptions in demand and model the network accordingly (Schrauf and Berttram 2016).

f. Cost optimization: The current era focuses on cost optimization using digital means. Although initial costs are high due to investments in infrastructure, there is a decline observed over time in running costs. The higher the technology usage, the higher the returns from a system with Digital Supply Chain efficiencies.

g. Scalability: Digital Supply Chains enable a quick scale-up or -down basis. Real-time information flows directly from the market through a supply chain to the supplier. This further reduces non-value-adding activities in a chain and allows easy scalability. The effective utilization of digital technologies in a supply chain also reduces environmental issues emerging from the supply chain (Bechtold et al. 2014).

Supply Chain Management Challenges:

- Supply Chain Management in the current era has transformed into a complex process with planning at multi-echelon levels and competition in different geographical areas to serve different types of customers (Johnson 2006; Lambert and Enz 2017).
- A supply chain network has to mitigate risks due to globalization, varied government policies, cultural differences, and changing customer behaviors (Sarpong 2014; Ivanov et al. 2018).
- An inefficient supply chain inherits issues such as pilferage and fraud, leading to distrust. There is absolutely no information sharing between relevant stakeholders, creating huge inventory pileups. The traceability of products is an associated, and the single largest, challenge without the information. A lack of transparency complicates a supply chain's management with reliability and competency issues (Costa et al. 2013).
- Demand capture is another big issue that produces for supply chains huge costs since it gives the initial stimuli to an entire system. Demand capture error, such as the "Bullwhip effect", leads to the issue of overproduction and restricted cash flows (Lee et al. 1997).
- The success of a product depends upon the process standardization and automation achieved thereof. Isolated processes carried out in silos create many issues, such as a high lead time for innovation and new business models (Farahani et al. 2017).

Blockchain-Based Digital Supply Chain:

Blockchain assists in electronic recordkeeping along with the verification and validation of data. Stated simply, the IoT and smart contracts are integral parts of the blockchain technology used in Supply Chain Management. It calls for an advanced usage of smart contracts and distributed ledgers, such that each node contains the requisite data. Blockchain is characterized by five core capabilities, i.e., visibility, aggregation, validation, automation, and resilience, which support a sustainable SCM. It helps an organization navigate amidst the complexity and volatility prevailing in the environment. Blockchain becomes more effective and efficient with (Chang et al. 2022):

a. Its complementation with the Internet of Things;
b. The recording of every transaction;
c. Data standardization;
d. The deployment of advanced analytics.

For organizations and managers, the data are available in a transparent way. The records stored in the distributed ledgers cannot be modified or deleted and bound by governance. The data in the blockchain are the source of truth for all associated systems (Krithika 2022). When blockchain was introduced, it was primarily emerging as a financial sector technology leading the digital space. However, in the past decade, researchers from the industry and academicians have emphasized the other application of blockchain. Blockchain offers some cutting-edge advantages such as speed, security, traceability, immutability, transparency, and, most important for the governance of the data, accessibility and visibility (Chiacchio et al. 2022). One of the most important used cases wherein blockchain creates a significant impact is Supply Chain Management with digital technologies (Gatteschi et al. 2018). Blockchain is characterized by features such as a decentralized and distributed infrastructure. This enables organizations to drive away the challenges of visibility, information sharing, and trust among different supply chain actors that usually lead to the collapse of a complete supply chain framework (Weber et al. 2016). Transparency addresses the overall visibility in a supply chain to enhance trust amongst stakeholders. It defines the extent to which all the stakeholders in a supply chain can have access to the information in the blockchain without any delay or noise. Transparency and traceability are not interchangeable, yet they are linked. Traceability contributes to the transparency of a system. The auditable distributed ledgers in blockchain invoke overall trust in a system. The efficiency of a system is multi-fold with the integration of technologies such as the Internet of Things (Sunny et al. 2020).

Blockchain enhances the security of transactions by encrypting and simultaneously provides cost benefits to a Digital Supply Chain. Primarily, blockchain uses integration over the internet and has an integrated model, which can involve multiple-to-multiple (i.e., many-to-many) types of connectivity and integration.

Maintaining an open distributed ledger without the identification of the parties is one of the prime features of blockchain. All the nodes obtain a copy of the information. In case of any modification to a transaction, a new block is created and chained to the previous chain, while the data are matched at periodic intervals. No parties need to break into the ledger data as they are publicly shared with a key. Even if one enters and changes or creates a new transaction, a new block is created. The identities of a buyer and seller are governed by the key shared. The seller initiating a particular transaction sends the key to the buyer, and, in case it is missed, another key is generated by the sender. This creates a new block and security message (Xu et al. 2016; Järvensivu and Törnroos 2010). Business transactions over the network are conducted with the help of smart contracting. It contains commonly agreed terms (such as payment, confidentiality, etc.) that minimize exceptions and the need for third-party intermediaries. This makes the monitoring automatic and cost-effective. Blockchain makes smart contracts possible for single and multiple transactions, even globally. Smart contracts, even though sounding like financial transactions, are operational and very flexible in nature and can be easily deployed for transaction automation in a DSC (Xu et al. 2016). Therefore, it is observed that blockchain provides security and flexibility at a lower cost. Thus, blockchain improves the efficiency of supply chains with improved information security and flexibility at a much lower cost since the third-party intermediaries are eliminated. Based on the above understanding, the following are the benefits of a Blockchain-Based Digital Supply Chain (Eljazzar et al. 2018):

a. Enhancement of trust due to the visibility different stakeholders acquire with data transparency in the supply chain network.
b. For some of the transactions, blockchain can also create a different structure that is transparent and decentralized.
c. Blockchain can be easily deployed in the global supply chain network.
d. For asset tracking, blockchain creates a decentralized and immutable system of digital assets.
e. Blockchain enables services and value creation in the network in a cost-effective way.
f. Digital asset creation, tracking, and sharing are made possible with blockchain maintaining the information security norms and guidelines.
g. Blockchain augments the accuracy of demand forecasts significantly.

3. Conceptual Research Model

Hypothesis Formation:

Every organization has a business model for conducting business to create value for shareholders. All businesses intend to generate profit. There are different strategies outlined by an organization to show the way business would be carried out (Shafer et al. 2005; Casadesus-Masanell and Ricart 2010). In the current era, the most important part of business is business model innovation targeted toward technological developments, customer preferences, and governance. The sole purpose of business model innovation is to find a new business logic for creating stakeholder value. The focus is on generating revenues through new opportunities, defining value propositions for customers, and maintaining relationships with all chain stakeholders, including suppliers (Amit and Zott 2001; Magretta 2002). Digital Supply Chains ensure data are generated in each customer interaction with digital technologies such as the Internet of Things. These data are stored in a central repository and used in business analytics models for fact-based decision making (Korpela et al. 2017). Thus, the researchers posit:

H1: *Business models and strategies developed by companies contribute towards the effectiveness of a Blockchain-Based Digital Supply Chain.*

By definition, a supply chain encompasses different stakeholders such as suppliers, manufacturers, distributors, retailers, and customers. The connection established between them is usually through products, cash-flows, information, and automated decisional workflows. Traditionally, these individual actors of a supply chain used to focus on individual performances without thinking or contributing towards the global supply chain objective. This injects many inefficiencies into a system from the organizational perspective (Lambert and Cooper 2000). This was identified by the researchers and managers in an organization. They pitched the idea of creating long-term coordination with these individual actors. This was to improve the supply chain's effectiveness and efficiency so the organization could become competitive in the market. The business environment is becoming more demanding every moment, with customers demanding personalization in every business transaction and interaction (Stefanou et al. 2003). It is becoming very difficult for organizations to maintain a supply and demand equilibrium simultaneously with inventory levels rising. Organizations need information-sharing platforms wherein information can be dynamically shared and inputted into decision-making models. Information-sharing platforms ensure that information is shared with the right stakeholders in a supply chain, and every transaction datum is stored as a block in the chain (Fiala 2005). Hence, the researchers propose:

H2: *Information platforms implemented by companies contribute towards the effectiveness of a Blockchain-Based Digital Supply Chain.*

In the current market, organizations would want all their business processes to be executed to meet the common objective seamlessly. An organization's efficiency is lowered significantly with uncoordinated and non-standard processes. Standardizing a business process primarily means forming a common business process as the basis benchmark and experience to be followed by all. It is similar to a template that every business process owner needs to follow in an organization. Business processes and standards require considerable governance to validate that the defined business processes are followed (Tregear 2014). A Digital Supply Chain includes deploying information technology and implementing digital technologies such as the Internet of Things to monitor business processes. Sensors in the landscape collect the change-of-state information and transmit the data over the internet to a central repository. Deviations can be validated, and corrective actions can be taken in real-time with the information being shared over the blockchain (Korpela et al. 2017). Therefore, the researchers posit:

H3: *Business processes and standards formulated by companies contribute towards the effectiveness of a Blockchain-Based Digital Supply Chain.*

The integration required between the different stakeholders of a supply chain is becoming increasingly complex. Sharing customer demand across the network in the fastest possible way is critical for the efficiency of a Digital Supply Chain (Bunn 2000). The sensors from the Internet of Things implemented in a Digital Supply Chain collect the change-of-state data and transmit them over the internet to a central repository. There is an implicit need for a platform that operationally integrates the complete data transfer. The actors of a supply chain utilize this data to plan their operations. Transferring real-time data through a supply chain with the help of digital technologies and blockchain augmentation avoids operational challenges such as cash-flow blockages due to inventory pileups or dissatisfied customers due to poor order management. Strategic advantages such as an agile market response, cost savings, accuracy, and relevancy are achieved with the help of real-time data. The well-known demand management software systems are proactive with customer demand and have operational flexibilities (Croxton et al. 2002). Thus, the researchers posit:

H4: *Data-transfer integration enabled by companies to stakeholders contributes towards the effectiveness of a Blockchain-Based Digital Supply Chain.*

Organizations need to be flexible and aligned with volatile customer demands. Customer-centric organizations should deploy systems to gather customer data from all sources to understand customer demands. Due to the pervasive internet presence, complete product information, including its manufacturers, is available to customers. It is vital for organizations to remain customer-focused (Chen and Popovich 2003). Most of the time, organizations involve customers in the co-creation of innovation. All the interactions involving customers need careful attention to improve customer experience each time the customer gets in touch with an organization (Karimi et al. 2001). A Digital Supply Chain augmented with blockchain significantly improves operational efficiency, resulting in a better customer experience. This, finally, improves the level of customer satisfaction and, therefore, customer retention. Hence, the researchers propose:

H5: *An effective Blockchain-Based Digital Supply Chain has a positive influence on customer retention.*

Information management in a supply chain is vital as the planning of the entire supply chain depends on this information. Supply chain activities such as demand forecasting, transportation, inventory management, etc., are completely dependent on the data and information gathered by a Digital Supply Chain and shared with the help of a distributed ledger or blockchain. Transparency is achieved with the help of shared data throughout a supply chain. The flow of information is not restricted within organizational boundaries but also moves outside the boundaries to customers and suppliers; transparency results in trust between customers and an organization. Information is shared as transactions or digital assets in the blockchain architecture. Such sharing improves the collaboration among supply chain actors, assuring a win-win situation and improving profitability for an organization. It can be stated that the amount of data generated in a supply chain directly results in the accuracy delivered by the supply chain (Eljazzar et al. 2018). This ensures that an organization achieves and sustains market leadership. Hence, the researchers posit:

H6: *An effective Blockchain-Based Digital Supply Chain has a positive influence on market leadership.*

Based on the above understanding of the different variables and their impact on the Blockchain-Based Digital Supply Chain efficiency, the theoretical model is created, as shown in Figure 1:

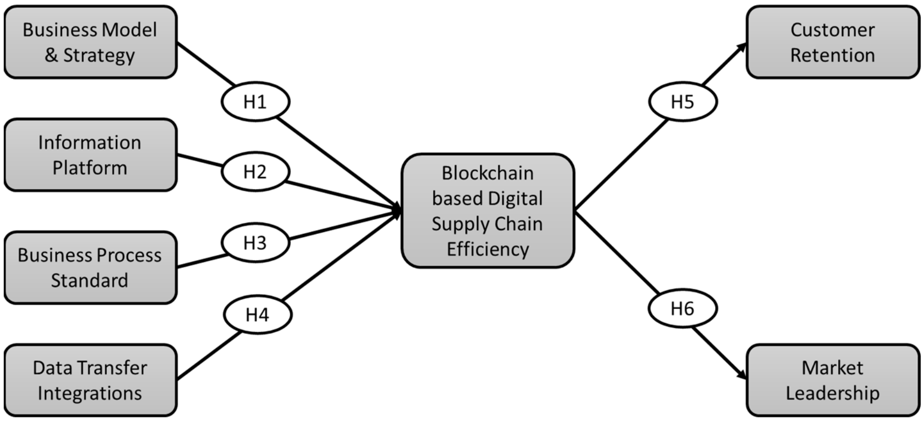

Figure 1. Conceptual model. Source: Authors' compilation.

4. Methodology

To validate the impact of the listed parameters resulting in customer retention and market leadership for the organization and to validate the hypotheses and the conceptual framework, we followed the following research methodology steps explained below. This section enables the replication and validation by other researchers of the steps taken and the reasons behind these steps. We start with the sampling technique and the methods used to ensure reliability and validity, followed by the methodology for analyzing and determining the results.

Sampling Technique: The Deliberate Sampling technique, also known as "Purposive Sampling", was deployed. The non-probability sample was to be chosen from the population. The choice of respondents depended on the research objective that was to be achieved. Since the aim was to validate the impacts of business and information technology parameters on the efficiency of a Blockchain-Augmented Digital Supply Chain, the respondents had to be an appropriate mix of business strategists and digital experts from the IT domain. The respondents had to be deep-rooted in the process and technology to respond appropriately to the structured questionnaire. The sampling frame design was such that there was a good blend of middle- and senior-level managers from the industry involved in strategy and digital roadmap building. The respondents in the sample represented the universe from which they were chosen based on their experience. This ensured fitting responses to the survey floated to them.

Threats to the right representation (Bias):

In statistical calculations, certain errors are likely to creep in due to various issues. Sampling, non-response, or coverage errors are some of the errors that were cured before conducting the analysis. The researchers in this study ensured unbiased responses by following certain steps. The researchers did not hire an interviewer to collect the responses from the respondents, which generally leads to biased conclusions. Care was taken to reach the respondents at their convenience, which fool proofed the researchers against a hassled retort. The next step was to reach out to only qualified and willing respondents who could give a genuine and accurate response, to a large extent foreclosing doubts on the rating scale errors.

Reliability Testing:

The capability of an instrument to reproduce the results is termed reliability. The researchers conducted reliability testing as the first step with the help of measures such as Cronbach's alpha, split-half correlation, and split–half with the Spearman–Brown adjustment. Cronbach's Alpha reported a value of 0.91, indicating higher levels of reliability, while 0.87 and 0.93 were the values calculated for split–half correlation and split–half with the Spearman–Brown adjustment, respectively. This further reinforced the reliability findings.

Data Analysis:

To conduct the analysis, the researchers deployed SPSS 22 and AMOS 21. The primary data gathered through the self-administered survey were coded and inputted into the system. The questionnaire was composed of statements that formed this study's latent variables. These statements were cited from credible research in the respective domain. An Exploratory Factor Analysis was conducted on the data to identify any underlying factors of the structure in the absence of any constraints on the output (Child 1990). For extracting the factors, the Principal Component Method with a varimax rotation was chosen. To validate the measurement model, a two-stage test was conducted. The first stage included validating the measurement model aided by a Confirmatory Factor Analysis (CFA). At the same time, the second stage scrutinized the relationships between the different variables considered in this study. This was strengthened by the Regression Weight Analysis for each dependent variable with the help of Structural Equation Modelling, a multi-regression technique.

Exploratory Factor Analysis (EFA)

It is a good practice to test the sampling adequacy of the data before we take forward the analysis to the EFA stage. A measure of sampling adequacy is Kaiser–Meyer–Olkin's (KMO) value. Calculations reported a KMO value of 0.74 with a Barlett's test significance at the *** level, i.e., $p < 0.000$. The results indicated higher values than those specified by Hair et al. (2013), i.e., 0.5 and 0.6 by Tabachnick and Fidell (2013). The extraction of factors was the basis of the eigenvalue of more than 0.6. The variance reported by the system was 75%.

Measurement Model Analysis:

In the statistical analysis, as a part of the first step, the validation of the measurement model was included. This was performed by conducting a Confirmatory Factor Analysis. The results of the first test run of the model are mentioned in Table 1. We can observe that poor model fit indices are reported. The index, i.e., Chi Sq/Df (i.e., Chi-Square divided by Degree of Freedom), was calculated as greater than the desired tolerance level of 3, i.e., (χ^2/df = 7.2). The model fit indices such as the goodness-of-fit index (GFI) equaled 0.689, and the adjusted goodness-of-fit index (AGFI) equaled 0.62, which was much less than the threshold value of 0.9. Another parameter to determine the goodness-of-fit is the root-mean-square error of approximation (RMSEA), which was 0.117 higher than the acceptable level of 0.05. Hence, all the statements were re-verified for their factor loadings, standard residuals, and modification indices. Statements that had factor loadings below the acceptable level of 0.7 were removed from the analysis. The revised model recorded many acceptable readings, and the model specification showed considerable improvement. The revised values are also inputted in Table 1 to compare with the previous values. The revised values indicated a chi sq/df value of 3.89~3, while the GFI and AGFI calculated were 0.87~0.9 and 0.8 closer to 0.9, respectively. The value of the RMSEA also improved drastically, with the value reported as 0.061. Based on the revised model fitness values, the revised model presents a much better fit compared with the initial model. Internal consistency testing uses a standardized cut-off value for each statement of 0.7 (Nunnally and Bernstein 1992; Hair et al. 2013). With the help of AVE, the convergent validity of the statements was conducted, the readings of which are mentioned in Table 2. All the values of AVE were observed to be greater than 0.5, which indicated that there was construct validity in the survey instrument. Fornell and Larcker (1981) determined the discriminant validity test used in this study. As per the standards set, the value of AVE was greater than the squared correlation between the constructs.

Table 1. CFA estimates.

Goodness-of-Fit Indices	Recommended Value	Initial CFA Model	Revised CFA Model
Chi Sq/Df	1–3	7.2	3.89
GFI	≥0.9	0.689	0.87~0.9
AGFI	≥0.9	0.62	0.8
RMSEA	≤0.05	0.119	0.061

Source: Authors' compilation.

Table 2. Construct reliability and convergent validity.

Latent Variable	Observed Variable	Standard Loadings (>0.7)	CR (>0.7)	AVE (>0.5)
Business_Model_Strat	BMS1	0.763	0.846	0.597
	BMS2	0.754		
	BMS4	0.837		
	INP2	0.699		
Information_Platform	INP4	0.791	0.819	0.596
	DTI1	0.787		
	INP3	0.7		
Business_Process_Std	BPS1	0.815	0.846	0.646
	BPS2	0.83		
	BPS3	0.73		
Data_Transfer_Int	DTI2	0.799	0.797	0.658
	DTI3	0.812		

Source: Authors' compilation.

Analysis of Structural Model:

A Structural Model Analysis was performed to test the proposed model. The values indicated a positive impact for all the input parameters as per the conceptual model of a Blockchain-Augmented Digital Supply Chain, while the weights of each of the linkages varied. Although standards demand the model fit indexes to be between 0.5 and 0.8 for social science studies, in this study, the values of the GFI, AGFI, and normed fit index (NFI) were in the range of 0.8–0.9, which indicates the good fit of the model. The path analysis table depicts the importance of the different parameters on the Blockchain-Augmented Digital Supply Chain efficiency. The most critical parameter for the success of the Blockchain-Based Digital Supply Chain efficiency revealed by this study was the data transfer integration. This parameter, as per the primary data analysis conducted with the help of SEM, scores the highest regression weight, denoting the importance of data transfer in supply chain operations. Transactional data captured are vital for an organization and managerial decision making. The data are fed into different analytical models to derive meaningful insights that safeguard a firm's market position.

The next important parameter, as per the regression weight assigned by the model, is the information platform, which is rightly so. Logically, if data are fueling a supply chain, then integrating them over an information platform becomes the next obvious step. This further reveals the importance of data sharing if the organizational objective is to execute the Digital Supply Chain seamlessly to compete in the market. Although business process standardization stands third as per the analysis, the researchers feel it is equally important. The standardization of business processes enables excellence in every customer transaction with uniform processes. The SEM revealed the positive influence of the business model parameter even though the weightage calculated was relatively less. This could be because of the fact that other parameters were viewed as more important by the respondents under the assumption that businesses will always have a business model strategy to compete in the market. The Table 3 below depicts the Path Analysis.

Table 3. Path Analysis.

		Path	Standard Regression Weight	Significance Level	Status
Business_Model_Strat	to	Blockchain based Digital SC Efficiency	0.16	0.023	Supported
Information_Platform	to	Blockchain based Digital SC Efficiency	0.32	***	Supported
Business_Process_Std	to	Blockchain based Digital SC Efficiency	0.22	0.004	Supported
Data_Transfer_Integration	to	Blockchain based Digital SC Efficiency	0.43	***	Supported

*** means $p < 0.001$. Source: Authors' compilation.

5. Discussion

There is a flurry of digital business models that are introduced into the market daily. These business models are strongly supported by digital technologies that are constantly evolving and innovating. Possibly a decade and more ago, when the Internet of Things was becoming popular and finding its place in most business processes, it was not easy to envisage technologies such as Machine Learning, Artificial Intelligence, and blockchain and their significance in business processes (Gartner 2014; Brody 2017). Similarly, in traditional business processes, logistics was the most vital element of any business. However, the term Supply Chain Management was introduced based on the fundamental principles of innovation through co-creation. A firm's dependency on its supply chain has increased tremendously. A supply chain includes all the stakeholders within, as well as external to, an organization, such as suppliers and customers. Businesses started competing in the market, not as brands, but instead as supply chains (Lambert and Cooper 2000). This created an inherent need for data generation and information sharing with all the relevant stakeholders. The business models and strategies were altered with innovations such as new products, new manufacturing methods, and new supply sources, markets, and business processes. Business model innovation means finding and establishing newer ways to generate value through the value chain for every stakeholder and offering value propositions to customers. A business model and strategy that is implemented impacts the entire organization (Amit and Zott 2001). In the past, innovative business models have resulted in sustainable businesses even in competitive external environments. Business models are vital for a firm's longevity, and a strategy to implement them is crucial for revenue generation. To compete in the market, organizations need to have a business plan and strategy to implement a Blockchain-Based Digital Supply Chain to ensure customer retention and market leadership.

To operationalize a business plan and strategy, huge volumes of data are required. Business analysts analyze the data and, with the help of techniques such as simulation, etc., develop an appropriate business model for an organization (Chae and Olson 2013). In the case of a Blockchain-Augmented Digital Supply Chain, several stakeholders start from the customer to the end supplier, who primarily supplies to the manufacturer or distributor. To plan effectively, the data need to be shared with all the stakeholders who subscribe to their relevant data block. The data are published over the integration platform that brings all the stakeholders together, and, based on the relevancy of information, the transactional data stored as a block are exposed (Eljazzar et al. 2018). The statistical analysis also supports this hypothesis positively with a descent regression weight pointing towards its importance in the Blockchain-Based Digital Supply Chain model.

A Blockchain-Augmented Digital Supply Chain functions on the transactional data captured automatically during every interaction with a customer. These data are transmitted through the supply chain efficiently, and relevant information is shared over the information platform with the appropriate stakeholders. The data transmitted over the internet are stored in a central repository and consumed by different business analytics models (Yerpude and Singhal 2017). The consumption of data is effective with normalized and structured data sets. This calls for business processes to be standardized. Unstructured and non-standard processes lower an organization's efficiency and simultaneously make the data models redundant quickly (Blumberg and Atre 2003).

Moreover, standard business processes offer a uniform customer experience which is preferred by the customer. Excellence in customer experience results in customer satisfaction and, finally, in customer retention (Berry et al. 2002). The primary data analysis supports this argument, demonstrating a positive influence of the parameter on the efficiency of the Blockchain-Based Digital Supply Chain.

Previous studies have proven that the supply chain process is vital for businesses. An organization's success depends on the interactions between the different stakeholders and the flow of information, materials, and equipment. Value propositions to customers are offered based on the value generated in a supply chain, wherein all the stakeholders participate and co-create innovation (Eljazzar et al. 2018). There is an inherent need to create data transfer integrations from various customer interaction points to the information platform. Every piece of information which is related to the customer is crucial for a customer-centric organization. In the case of a Blockchain-Based Digital Supply Chain, the data are automatically captured by the Internet of Things implemented in the organization. The change-of-state data collated by the sensors are transmitted over the internet. This real-time data mitigates challenges such as obsolescence and the blockage of capital in non-moving inventories and operational issues such as inventory pile-up resulting in dissatisfied customers (Rainbird 2004). Data transfer integration ensures that organizations can respond to customer demand with requisite agility and, at times, pre-empt the market demand. This directly impacts customer satisfaction and, finally, customer retention. Customer-focused organizations gain market leadership with customers remaining connected and organizations being able to derive customer lifetime value (Homburg et al. 2000). The primary data analysis reinforces the above understanding, revealing a positive influence of this parameter on the Blockchain-Based Digital Supply Chain efficiency, with the highest regression weight.

6. Conclusions

New-age digital technologies are disrupting traditional supply chains. Information is the common thread between all the stakeholders of a Digital Supply Chain. In the current market situation wherein customer demand is volatile, and behavior is unpredictable, it is extremely important to pass the demand data through a supply chain in the fastest possible manner. The efficiency of a Digital Supply Chain depends majorly on the four parameters considered in this study, i.e., business model and strategy, the information platform, business process standardization, and data transfer integration. The primary data analysis conducted as a part of this study accords significant priority to data transfer integration and, next, to the information platform. This study offers some important take-aways for the researchers, industry, and academicians. It emphasizes the requirement of data transfer integration and an information-sharing platform for making a Blockchain-Based Digital Supply Chain effective and efficient. A Digital Supply Chain is fundamentally a value-driven smart process to create new innovative ways for revenue generation (Rainbird 2004). Businesses adopt new models and approaches extensively using analytics models built on strong fundamentals and tested business processes. A Digital Supply Chain is not about handling digital goods but using digital methods to manage the supply chain. With the augmentation of blockchain, we have evaluated that those significant tangible benefits are achieved along with intangible benefits such as trust and loyalty (Farahani et al. 2017). Data transfer integration and information sharing platforms become the backbone of a Blockchain-Augmented Digital Supply Chain. The literature review conducted by the researchers aided the understanding of the parameters impacting the efficiency of a

Blockchain-Augmented Digital Supply Chain. Thereafter, the primary data analysis reinforced the impact of the parameters with a positive influence on supply chains, revealing the gravity of each parameter's impact with the help of regression weights.

7. Limitations

The current study focuses on understanding a Digital Supply Chain with augmented blockchain technology. It emphasizes the four most important parameters that may impact the efficiency of a supply chain, i.e., business model strategy, information platform for sharing the information with stakeholders, business process standardization across the chain, and the integrations required for the transfer of data. However, we take certain underlying assumptions in this study that can be treated as limitations of the study, such as:

a. All the stakeholders agree to share the transactional data.
b. The manufacturers are comfortable sharing the inventory information.
c. The skillset possessed by the operators is good enough to maintain the system.
d. The firms are willing to invest in information technology and digital solutions.
e. The network connectivity is seamless.

8. Future Research Directions

Blockchain is an emerging area that has erupted, exploring the cryptography domain but not implemented to its fullest potential (Hughes et al. 2019). Primarily, businesses have not looked much beyond bitcoin. Blockchain, as mentioned in this current study, can enable significant process improvements imbibing agility in an entire Digital Supply Chain. However, privacy and security must be prioritized to enjoy the full benefits of blockchain implementation. The researchers in the current study did not explore the information security aspect of data transfers enabled over the blockchain. The study of information security safeguarding an organization's data and privacy features is a completely different subject and cannot be explored in conjunction with any other topic. Therefore, the researchers suggest that the basis of the current study is that if the security aspects can be studied and validated as a part of the next steps, the findings will become invaluable in the body of knowledge and for industry practitioners. In the new information technology domain, wherein a supply chain is transformed into a Digital Supply Chain, data privacy and security are the most relevant things which ideally should be taken up for solution. The Digital Supply Chain concept is sharing data with all the stakeholders in a supply chain within and external to the organization. The data become more valuable if the consumption point is beyond the organizational boundaries. Strict governance and controls must be exercised on the deployed data-sharing model, platform, and technologies. Integrated supply chain models are the models that are used currently and would find more applications in the future. Therefore, the information security and privacy aspects have inherently become the priority for further study in this domain.

Author Contributions: Conceptualization, S.Y.; methodology, S.Y., S.G. and K.S.; software, S.Y., S.G. and K.S.; validation, S.Y., S.G. and K.S.; formal analysis, S.Y., S.G. and K.S.; investigation, S.Y., S.G. and K.S.; resources, S.Y., S.G. and K.S.; data curation, S.Y., S.G. and K.S.; writing—original draft preparation, S.Y., S.G. and K.S.; writing—review and editing, S.G.; visualization, S.Y., S.G. and K.S.; supervision, S.G. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Data Availability Statement: All data are found in this paper.

Conflicts of Interest: The authors declare no conflict of interest.

Abbreviations

Abbreviation	Full Form
DSC	Digital Supply Chain
PKI	Public Key Infrastructure
RFID	Radio Frequency Identification
GPS	Global Positioning System
IoT	Internet of Things
SCM	Supply Chain Management
SCOR	Supply Chain Operations Reference
SPSS	Statistical Package for Social Sciences
AMOS	Analysis of Moment Structures
CFA	Confirmatory Factor Analysis
SEM	Structured Equation Modelling
EFA	Exploratory Factor Analysis
KMO	Kaiser - Meyer - Olkin's
Df	Degree of Freedom
GFI	Goodness of Fit Index
AGFI	Adjusted Goodness of Fit Index
RMSEA	Root Mean Square Error of Approximation
AVE	Average Variance Extracted
NFI	Normed Fit Index
JSON	JavaScript Object Notification
API	Application Programming Interface

Source: Authors' compilation.

References

Ambe, Intaher Marcus. 2009. Agile Supply Chain: A Strategy For Competitive Advantage. Paper ptesented at the 5th International Strategic Management Conference, "Striking the Right Balance Between Existing Strategy and New Opportunities with Special Emphasis on Turbulent Markets", Stellenbosch, South Africa, June 2–4; pp. 659–70.

Amit, Raphael, and Christoph Zott. 2001. Value creation in e-business. *Strategic Management Journal* 22: 493–520. [CrossRef]

Atzori, Luigi, Antonio Iera, and Giacomo Morabito. 2010. The Internet of things: A survey. *Computer Networks* 54: 2787–805. [CrossRef]

Baker, J., and J. Steiner. 2015. Blockchain: The Solution for Supply Chain Transparency, Provenance. Available online: https://www.provenance.org/whitepaper (accessed on 22 September 2022).

Bechtold, Jochen, Christoph Lauenstein, Andreas Kern, and Lena Bernhofer. 2014. Industry 4.0-The Capgemini Consulting View. *Capgemnini Consulting* 31: 4–32. Available online: https://www.capgemini.com/consulting/wp-content/uploads/sites/30/2017/07/capgemini-consulting-industrie-4.0_0_0.pdf (accessed on 10 October 2022).

Berry, Leonard L., Lewis P. Carbone, and Stephan H. Haeckel. 2002. Managing the total customer experience. *MIT Sloan Management Review* 43: 85–89.

Blumberg, Robert, and Shaku Atre. 2003. The problem with unstructured data. *Dm Review* 13: 62.

Bowersox, Donald. J. 1997. Integrated supply chain management: A strategic imperative. Paper presented at the Council of Logistics Management 1997 Annual Conference, Chicago, IL, USA, October 5–8.

Brody, Paul. 2017. *How Blockchain Is Revolutionizing Supply Chain Management*. Walldorf: SAP. Available online: http://www.digitalistmag.com/tag/blockchain-and-supply-chain (accessed on 10 July 2022).

Bunn, Derek W. 2000. Forecasting loads and prices in competitive power markets. *Proceedings of the IEEE* 88: 163–69. [CrossRef]

Büyüközkan, Gülçin, and Fethullah Göçer. 2018. Digital Supply Chain: Literature review and a proposed framework for future research. *Computers in Industry* 97: 157–77. [CrossRef]

Casadesus-Masanell, Ramon, and Joan Enric Ricart. 2010. From strategy to business models and onto tactics. *Long range Planning* 43: 195–215. [CrossRef]

Chae, Bongsug, and David L. Olson. 2013. Business analytics for supply chain: A dynamic-capabilities framework. *International Journal of Information Technology & Decision Making* 12: 9–26.

Chang, Ai, Nesreen El-Rayes, and Jim Shi. 2022. Blockchain technology for supply chain management: A comprehensive review. *FinTech* 1: 191–205. [CrossRef]

Chen, Injazz J., and Karen Popovich. 2003. Understanding customer relationship management (CRM): People, process and technology. *Business Process Management Journal* 9: 672–88. [CrossRef]

Chiacchio, Ferdinando, Diego D'Urso, Ludovica M. Oliveri, Andrea Spitaleri, Concetto Spampinato, and Danilo Giordano. 2022. A Non-Fungible Token Solution for the Track and Trace of Pharmaceutical Supply Chain. *Applied Sciences* 12: 4019. [CrossRef]

Child, Dennis. 1990. *The Essentials of Factor Analysis*. London: Cassell Educational.

Costa, Corrado, Francesca Antonucci, Federico Pallottino, Jacopo Aguzzi, David Sarriá, and Paolo Menesatti. 2013. A review on agri-food supply chain traceability by means of RFID technology. *Food and Bioprocess Technology* 6: 353–66. [CrossRef]

Crosby, Michael, Pradan Pattanayak, Sanjeev Verma, and Vignesh Kalyanaraman. 2016. Blockchain technology: Beyond bitcoin. *Applied Innovation* 2: 71.

Croxton, Keely L., Douglas M. Lambert, Sebastián J. García-Dastugue, and Dale S. Rogers. 2002. The demand management process. *The International Journal of Logistics Management* 13: 51–66. [CrossRef]

Drucker, Peter Ferdinand. 1998. Management's new paradigms. *Forbes Magazine* 10: 98–99.

Eljazzar, Maged M., Mohammed A. Amr, Sally S. Kassem, and Mohamed Ezzat. 2018. Merging supply chain and blockchain technologies. *arXiv* arXiv:1804.04149.

Farahani, Poorya, Christoph Meier, and Jörg Wilke. 2017. Digital supply chain management agenda for the automotive supplier industry. In *Shaping the Digital Enterprise*. Cham: Springer, pp. 157–72.

Fiala, Petr. 2005. Information sharing in supply chains. *Omega* 33: 419–23. [CrossRef]

Fornell, Claes, and David F. Larcker. 1981. Structural equation models with unobservable variables and measurement error: Algebra and statistics. *Journal of Marketing Research* 18: 382–88. [CrossRef]

Gartner. 2014. Hype Cycle for Emerging Technologies Maps the Journey to Digital Business. Available online: http://www.gartner.com/newsroom/id/2819918 (accessed on 13 August 2019).

Gatteschi, Valentina, Fabrizio Lamberti, Claudio Demartini, Chiara Pranteda, and Víctor Santamaría. 2018. Blockchain and smart contracts for insurance: Is the technology mature enough? *Future Internet* 10: 20. [CrossRef]

Hair, Joseph F., Jr., Christian M. Ringle, and Marko Sarstedt. 2013. Partial least squares structural equation modeling: Rigorous applications, better results and higher acceptance. *Long Range Planning* 46: 1–12. [CrossRef]

Homburg, Christian, John P. Workman, and Ove Jensen. 2000. Fundamental changes in marketing organization: The movement toward a customer-focused organizational structure. *Journal of the Academy of Marketing Science* 28: 459–78. [CrossRef]

Huan, Samuel H., Sunil K. Sheoran, and Ge Wang. 2004. A review and analysis of supply chain operations reference (SCOR) model. *Supply Chain Management: An International Journal* 9: 23–29. [CrossRef]

Hughes, Laurie, Yogesh K. Dwivedi, Santosh K. Misra, Nripendra P. Rana, Vishnupriya Raghavan, and Viswanadh Akella. 2019. Blockchain research, practice and policy: Applications, benefits, limitations, emerging research themes and research agenda. *International Journal of Information Management* 49: 114–29. [CrossRef]

Ivanov, Dmitry, Suresh Sethi, Alexandre Dolgui, and Boris Sokolov. 2018. A survey on control theory applications to operational systems, supply chain management, and Industry 4.0. *Annual Reviews in Control* 46: 134–47. [CrossRef]

Järvensivu, Timo, and Jan-Åke Törnroos. 2010. Case study research with moderate constructionism: Conceptualization and practical illustration. *Industrial Marketing Management* 39: 100–8. [CrossRef]

Jayabalasamy, Guruprakash, and Srinivas Koppu. 2021. High-performance Edwards curve aggregate signature (HECAS) for nonrepudiation in IoT-based applications built on the blockchain ecosystem. *Journal of King Saud University-Computer and Information Sciences*. *in press*. [CrossRef]

Johnson, M. Eric. 2006. Supply chain management: Technology, globalization, and policy at a crossroads. *Interfaces* 36: 191–93. [CrossRef]

Karimi, Jahangir, Toni Somers, and Yash Gupta. 2001. Impact of information technology management practices on customer service. *Journal of Management Information Systems* 17: 125–58. [CrossRef]

Korpela, Kari, Jukka Hallikas, and Tomi Dahlberg. 2017. Digital supply chain transformation toward blockchain integration. Paper presented at the the 50th Hawaii International Conference on System Sciences, Waikoloa Village, HI, USA, January 4–7.

Krithika. 2022. Survey on the Applications of Blockchain in Agriculture. *Agriculture* 12: 1333.

Kshetri, Nir. 2018. Blockchain's roles in meeting key supply chain management objectives. *International Journal of Information Management* 39: 80–89. [CrossRef]

Lambert, Douglas M., and Martha C. Cooper. 2000. Issues in supply chain management. *Industrial Marketing Management* 29: 65–83. [CrossRef]

Lambert, Douglas M., and Matias G. Enz. 2017. Issues in supply chain management: Progress and potential. *Industrial Marketing Management* 62: 1–16. [CrossRef]

Lee, Hau L., Venkata Padmanabhan, and Seungjin Whang. 1997. Information distortion in a supply chain: The bullwhip effect. *Management Science* 43: 546–58. [CrossRef]

Lou, Ping, Quan Liu, Zude Zhou, and Huaiqing Wang. 2011. Agile supply chain management over the Internet of things. Paper presented at the 2011 International Conference on Management and Service Science, Bangkok, Thailand, May 7–9; pp. 1–4.

Lummus, Rhonda R., Dennis W. Krumwiede, and Robert J. Vokurka. 2001. The relationship of logistics to supply chain management: Developing a common industry definition. *Industrial Management & Data Systems* 101: 426–32.

Magretta, Joan. 2002. *Why Business Models Matter*. Boston: Harvard Business School, pp. 3–8.

Nunnally, Jum, and Ira Bernstein. 1992. *Psychometric Theory*. New York: McGraw-Hill, vol. 24, pp. 453–580.

Rainbird, Mark. 2004. Demand and supply chains: The value catalyst. *International Journal of Physical Distribution & Logistics Management* 34: 230–50.

Sarpong, Sam. 2014. Traceability and supply chain complexity: Confronting the issues and concerns. *European Business Review* 26: 271–84. [CrossRef]

Schrauf, Stefan, and Philipp Berttram. 2016. Industry 4.0: How Digitization Makes the Supply Chain More Efficient, Agile, and Customer-Focused. Available online: https://www.strategyand.pwc.com/gx/en/insights/2016/digitization-more-efficient.html (accessed on 7 June 2019).

Shafer, Scott M., H. Jeff Smith, and Jane C. Linder. 2005. The power of business models. *Business Horizons* 48: 199–207. [CrossRef]

Stefanou, Constantinos J., Christos Sarmaniotis, and Amalia Stafyla. 2003. CRM and customer-centric knowledge management: An empirical research. *Business Process Management Journal* 9: 617–34. [CrossRef]

Sunny, Justin, Naveen Undralla, and V. Madhusudanan Pillai. 2020. Supply chain transparency through blockchain-based traceability: An overview with demonstration. *Computers & Industrial Engineering* 150: 106895.

Szabo, Nick. 1997. Formalizing and securing relationships on public networks. *First Monday* 2. [CrossRef]

Tabachnick, Barbara G., and Linda S. Fidell. 2013. Using multivariate statistics: International edition. *Pearson* 2012: 1.

Tregear, Peter. 2014. *Enlightenment or Entitlement?: Rethinking Tertiary Music Education*. Platform Paper No 38. Sydney: Currency House.

Weber, Ingo, Xiwei Xu, Régis Riveret, Guido Governatori, Alexander Ponomarev, and Jan Mendling. 2016. Untrusted business process monitoring and execution using Blockchain. In *International Conference on Business Process Management*. Cham: Springer, pp. 329–47.

Xu, Xiwei, Cesare Pautasso, Liming Zhu, Vincent Gramoli, Alexander Ponomarev, An Binh Tran, and Shiping Chen. 2016. The Blockchain as a software connector. Paper presented at the 2016 13th Working IEEE/IFIP Conference on Software Architecture (WICSA), Venice, Italy, April 6–8; pp. 182–91.

Yerpude, Samir, and Tarun Kumar Singhal. 2017. Internet of Things and its impact on Business Analytics. *Indian Journal of Science and Technology* 10: 1–6. [CrossRef]