



Assessing Blockchain Adoption in Supply Chain Management, Antecedent of Technology Readiness, Knowledge Sharing and Trading Need

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Abstract

The present research aimed to establish a framework integrating the concept of technology readiness with variables that accomplished the blockchain adoption theory to identify the impact of blockchain adoption on supply chain transparency, blockchain transparency, and supply chain performance. The methodology used was quantitative with PLS-SEM as the analysis method. There were 295 validated datasets used. The procedure of data collection involved questionnaires. The key finding of the research confirmed the six proposed hypotheses. It was also confirmed that technology readiness, knowledge sharing, and trading needs were significant for the profitability of blockchain technology adoption in supply chain management. On the other hand, blockchain adoption played a significant role in supply chain transparency, blockchain transparency, and supply chain performance. The novelty of this research is in the integration of technology readiness into blockchain in the field of supply chain management. This research can be used to improve and analyze the success rate of blockchain adoption in supply chain management systems. The findings of this study contribute to several aspects, namely practical and academic implications, by providing more insights that correlate with blockchain integration into supply chain management systems.

Keywords:

Blockchain Adoption;
Technology Readiness;
Supply Chain Management;
Partial Least Squares.

Article History:

Received:	16	February	2022
Revised:	22	May	2022
Accepted:	06	June	2022
Available online:	28	June	2022

1- Introduction

The rapidity of technological advancement has imposed positive and negative impacts on many industries, one of which is the industry of logistics and supply chain management (SCM) [1-5]. Meanwhile, blockchain is one of the technologies adjusting the paradigm of business and industry. It modifies business processes, operations, and strategies [6-12]. The concept of a smart contract supported by the blockchain is beneficial for the digitalization process in any element of SCM. It also helps in the implementation of decentralization in a business model using reliable and protected programming algorithms. Both are the benefits of the use of SCM [9]. On the contrary, the drawback is disturbing the implemented business process and causing companies' lack of preparation to use blockchain technology [13].

Based on previous literature, blockchain technology can be a big challenge for SCM industries since the paradigm of SCM using the blockchain concept shifts the business element while enhancing the effectiveness and performance of the

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DOI: <http://dx.doi.org/10.28991/ESJ-2022-06-05-01>

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SCM [10, 14–20]. Another benefit is shortening the distribution time of products and services because of their direct access [21]. Blockchain has high performance to minimize the disturbance in the distribution process [17, 20]. Overall, blockchain technology would be one of the most adopted technologies in SCM because of its precise performance to be implemented. Previous studies have also revealed that the adaptation of blockchain to SCM could easily enhance the tracking performance [8, 14, 22–24]. Furthermore, research in the field of food security has found that the security aspect makes blockchain the preferred choice by users [22, 25]. Other studies have illustrated the use of blockchain in the wine industry [26] and health services [27]. The field of e-commerce uses this to manage the contract between customers and providers [28]. Focusing on the SCM, blockchain is adopted due to its capability of handling complex problems more effectively, like transparency and accountability [19, 26, 29, 30], security and resilience [31, 32], trust [33, 34], uncertainty [35], fraud [36] and budgeting [37]. Adapting blockchain to SCM seems to improve service effectiveness and efficiency, contributing to organizational sustainability. Therefore, its application has become a new key success factor in the SCM industry [22].

From the viewpoint of some researchers, blockchain is unaccustomed to SCM. The implementation of its technology is highly challenging in terms of user readiness, transparency, and business partner knowledge [12, 38, 39]. The empirical investigation of blockchain implementation is still limited and requires more significant literature [40]. Accordingly, the current empirical study aims to reduce the knowledge gap between the implemented blockchain technology in SCM and the integrated technological concept of readiness. Its basic concept is to examine the related variables and the correlated antecedent to get a deeper understanding of the users' behaviors in adopting blockchain technology, supply chain transparency, supply chain performance, and blockchain transparency. This study was conducted based on the literature corresponding to blockchain technology and is also supported by literature on the implementation of SCM in blockchain technology and the specific empirical studies on SCM and blockchain. Then, the study examines the collected data taken from Taiwan and Indonesia.

The contribution of the research is to enrich the literature on SCM along with blockchain technology and readiness technology concepts, especially in empirical studies. From the managerial aspect, this study contributes to the understanding of correlated variables and the adoption of blockchain and SCM in a framework that is validated to produce a strong correlation value. Therefore, the conclusion of the research shows that its theoretical aspect has a good eligibility standard that can be implemented in the research fields of blockchain and SCM. The research is organized systematically, beginning with the introduction and followed by establishing the strong construction of the theoretical framework, leading to five hypotheses. The method is arranged to explain the steps applied to solve the existing problems, including the analysis and validation of the collected data. The results are given in a descriptive way, and the deeper findings are explained in detail so that the conclusion and ideas for more research can be drawn.

There is plenty of research discussing technology readiness (TR), yet still restricted to integrating the concept of technology readiness and blockchain adoption, especially in SCM. There is a gap in measuring the SCM user perception of blockchain technology and the outcomes of blockchain adoption, including supply chain transparency, supply chain performance, and blockchain transparency. Therefore, the contribution and value of the current research to knowledge advancement, social impact, and managerial impact are supported. The contribution covers the framework development in measuring the performance of blockchain adoption and the role outcome that arises.

User behavior in blockchain integration and SCM affect the effectiveness of technology implementation. Consequently, the concept of technology readiness [22] is required as an antecedent variable for the identification and the standardization of user psychology and readiness toward the technology. The framework developed in this research is obtained from the results of method integration between technology readiness, blockchain technology, and SCM. It is applied to measure the level of perception and the performance of blockchain and SCM. The practical and academic advantages of the research is to be the reference and assessment method in promoting blockchain adoption. The involvement of antecedent variables of TR describes understanding the sustainability of blockchain adoption. The research starts by describing research gaps in the introduction and continues to explore the previous theories in the literature review part. Then, the third section of the study provides the research framework development and hypothesis, followed by describing information related to data collection, analysis software, etc., in section four. Section five focuses on the description of data (acceptance or rejection), followed by research analysis, discussion, and conclusion.

2- Literature Review

2-1- Blockchain Fundamentals

The concept of blockchain technology is initially used for cryptocurrency, and its substance lies in the database technology known as ledgers. The technology is designed based on a similar network scheme, according to which the collected and distributed information is valid and synchronized well to provide chains [12, 17, 33, 38, 41]. Risius and Spohrer [42] define blockchain technology as a distributed system that is used to store and distribute data or information and has a protected security aspect using the concept of cryptography. The concept of validation in blockchain technology involves the authoritative parties in its transaction. The excellence of this technology is in its transparency

and guarantee of past transaction validity. Hence, the use of a decentralized system causes the changes only to happen before the transaction validation [18]. Many researchers claimed that the technology resists error. Another excellency of this technology is its tracking of the transaction. This method helps the organization check the finished activity and transaction, enabling the arrangement of the history of the transaction based on its happening and forming blocks or chains [43].

The concept offered by the blockchain gives a big potential to improve SCM performance [16, 44]. For example, in the field of food distribution, blockchain is helpful to classify the food origin and ensure its distribution based on the existing nodes [25, 45, 46]. Research conducted by Thakur et al. [47] reported that blockchain could be utilized to manage land certificates using the concept of the smart contract. Other than that, its inferiority obstructs the implementation of internet infrastructure and the lack of knowledge. However, many researchers ensure that the technology is efficiently and effectively capable of supporting business processes, especially in the SCM industry [48, 49]. Integration of blockchain technology on SCM is beneficial to accelerate the development of a company [50]

2-2- Supply Chain Performance as a Result of Blockchain Integration

Definition of supply chain refers to the network of complex systems that correlates the nodes [51-53]. Despite the complexity, this system is very adaptive concerning its implementation [54]. The raw data processed by the system provides information and knowledge that is useful for the next business process. Pan et al. [55] proposed that the integration of blockchain in the supply chain gives significant and favorable distribution to maximize the performance of the supply chain while minimizing the budget. Hence, researchers agree that blockchain technology is adaptive to be integrated into SCM and transform the process structure of the supply chain [6-7, 10, 14]. Furthermore, its integration in SCM is helpful to run real-time tracking in supply chain activities [14]. Another advantage is the establishment of transparency in supply chain management that involves the existing members [7]. The concept of a distributed system adopted from blockchain technology in SCM can minimize the counterfeit risk and process the supply chain efficiently [6]. This technology broadens the changes in the other parts of the supply chain, including the field of manufacture [56]. The advantages obtained from the integration of blockchain in SCM can be seen in all the aspects of the supply chain business process. It minimizes the operational budget of the supply chain, maximizes accountability, and maintains the visibility and accountability of the supply chain process.

Performance efficiency and effectiveness of the supply chain generally become the purpose of the supply chain concept [57], attracting the attention of leading researchers to study the way of building and understanding the supply chain performance behavior [58-64]. Such studies reveal the significant and positive effects of the variables that take part as indicators to determine the interaction behavior in SCM. The established correlation facilitates the exchange of knowledge, innovation, and the performance improvement of logistics [65].

A review of the study conducted by White [66] shows that the integration of blockchain technology in SCM improves the activities and performance of business partners. In addition, Kamble et al. [15] confirmed that the supply chain industry focusing on agriculture resulted in an improvement in the industry performance, including the establishment of transparency in business processes, real-time tracing, and historical tracing to minimize the waiting time. According to Wong et al. [67], the integration of this technology into SCM broadens the visibility, keeps the data, and prevents the third party from getting involved in the business process (disintermediation). The advantages include the performance and operational improvements in the SCM business processes. A study carried out by Wagner and Bode [68] reviewed the risk of SCM classic concept that could be minimized significantly by the integration of the blockchain technology into SCM [19, 25], including the deviation and uncertainty of business processes.

As a superior technology, blockchain is anti-damage during or after transactions. In addition, the concept established from this technology gives transparency to business activity, ensures high accountability, provides real-time and historical tracking, and applies decentralization. Another advantage is solving the complicated problem of SCM business processes and uncertainty [35] because uncertainty in the concept of SCM is a drawback to the ongoing business process [68].

The results discovered by several researchers prove that reducing the cost of financing is essential in the integration of blockchain technology into SCM due to its complexity [19]. Furthermore, transparency and accountability in business processes are crucial to the effectiveness of data and information transfer [69], the acceptability of cooperation integrity [17], and the growth of trust in business relationships [19] as confirmed by Schmidt and Wagner [12]. However, the technology is also challenging concerning the privacy of data and information issues, the reliability of the data, and the connectivity of the internet and network.

Babich and Hilary [38] explain the advantages and disadvantages of blockchain technology on SCM, especially in operation management. The advantages lay in the statement of performance visibility, aggregation, data, and information. Meanwhile, the disadvantages revolve around its issues of information security and privacy and the unestablished aspect of the standard. The present research proposes several hypotheses of concrete and detailed

conceptual models to give an understanding of the correlation between the existing variables in blockchain integration with SCM. Table 1 displays the questionnaire items of the research in building and constructing its definition using the tested scientific standard [70, 71]. The forthcoming steps are to elaborate and implement in the right sequence, starting from the conception of the definition, establishing the definition, and formulating and accomplishing the framework.

2-3- Technology Readiness

The concept of Technology Readiness (TR) refers to an individual perception of the new technology, either accepting or rejecting it [22]. It relates to individual certainty in choosing the new technology [34]. The concept is usually used to measure user satisfaction while dealing with the new technology, especially in the field of information and communication, and to measure user reactions [40]. TR is also used to measure customer perception [21]. Many researchers have declared that TR is utilized to measure users' reactions to the up-to-date technologies, providing information about their perceptions, either positive or negative. The positive perception shows the variables of optimism and innovation, while the negative perception reflects discomfort and insecurity.

Services provided by blockchain integration into SCM lead to a relatively new system of information technology, affecting the elements that interact within the systems. In deciding to adopt new technologies, the objective benchmark of assessment to user acceptance is required [41]. The concept of TR can predict user perception of the new technology by precise measurement [9]. TR has the potential to describe the personality values of the new technology users effectively. This is similar to blockchain integration into SCM, which is challenging to the users. The concept designed by Parasuraman [22] and Venkatesh et al. [9] provides four variables that can be used as a benchmark of TR and include optimism, innovation, discomfort, and insecurity. Table 1 summarizes the definitions and references of the constructs involved in this research.

Table 1. Operational definitions

Construct	Definition	Source
Knowledge sharing	Knowledge sharing refers to the exchange of knowledge among the companies by their SC members. Using blockchain, users coming from similar SCs are allowed to share information in real-time, including their skills on the system, the best practice, and the potential utilization of SCM processes.	Tian (2017), Abubakar et al. (2017), Ramayah et al. (2014), Yi (2009)
Trading need	The trading partner relationship refers to a business relationship that involves two or more organizations or customers. The common configuration of trading partners lies in its organization and supplier.	Angeles & Nath (2000), Wamba et al. (2020)
Blockchain Adoption	A significant technology utilized by organizations to develop, implement, and manage their business. It assists in integrating different business partners in the SCM, contributing to a more reliable environment. Adopting blockchain technology helps organizations to achieve meaningful performance improvement in the supply chain network.	Hung (2021)
Supply chain Transparency	It refers to the level of transparency within the supply chain network.	Pizzuti & Mirabelli (2015), Thakur et al. (2019)
Blockchain Transparency	It refers to the level of transparency within the blockchain network.	Pizzuti & Mirabelli (2015), Thakur et al. (2019)
supply chain performance	It is generally achieved or enhanced by increasing the complexity, mainly because of the number of available technologies and the issue of information asymmetry. In such circumstances, blockchain technologies are welcomed not only to tackle such cases of complexity but also to promote and improve performance.	Qrunfleh & Tarafdar (2014); Hyperledger (2019), Maersk (2018)
Technology readiness	It is regarded as personality traits that increase the adoption of novel technologies to accomplish private or work-related goals	Parasuraman (2000); Lin et al. (2007), Lin & Hsieh (2012)

3- Development of Research Hypotheses

3-1- Technology Readiness

The positive perspective of a novel technology encourages the assurance of the concrete advantages of that technology from the aspect of flexibility to the performance effectivity [21, 22, 41, 55-57]. Positivity and optimism of the users arise from their security and the ease of technology usage. Studies conducted by many researchers prove that the main factor of positivity coming from the user is optimism and innovation, while negativity relates to discomfort and insecurity [57, 58]. Generally, the novelty of innovation and technology in an industry motivates the users to master it [59]. The motivation adapts the users to the novel technology adopted. On the contrary, an ineffective technology arises a negative perception and necessitates some efforts to utilize the technology [21, 41, 57, 60]. Further consideration of the technology leads to the problems of security. The related study will be more complex for adopting the novel technology.

The concept of TR has been implemented and discussed in achieving an accurate benchmark of individual perception value to the most recent technology in the field of trading, online services, health services, and education services. A

study directed by Lin et al. [61] verified the correlation of user behavior in adopting recent technologies and measured the significance of the values in the prevailing variables. Other studies have also provided similar findings [58, 62, 63]. The correlation and the significance of adopting the latest technologies provided by the literature review help the researcher in raising the following hypothesis.

Hypothesis 1 (H1): Technology readiness gives significant outcomes and provides positive values for blockchain adoption.

3-2- Trading Partner Pressure

The correlation between trading partners mainly contributes the highest value. The relationship between the two parties cannot be parted from the suppliers and receivers, especially in the SCM industry. The prevailing systems in SCM have to build configurations between the colleagues to assure the well-running of the systems [72]. In SCM, the nodes between the related networks in the chain are relatively complicated. The readiness of both two parties becomes prominent, especially in infrastructure and resources to optimize the running systems [73]. Another aspect is encouraging the partners to prepare for the blockchain integration and build the related stakeholder understanding [74] to support the readiness of blockchain integration [75-77]. Previous researchers explain that pressure is necessary for the engaged stakeholders in integrating the technology, and it affects the integration process in blockchain technology [74, 78]. Accordingly, the second research hypothesis is formed as follows.

Hypothesis 2 (H2): Trading needs give a great influence and provide positive value to blockchain adoption.

3-3- Knowledge Sharing

Innovation is principal for enhancing performance effectiveness in organizations or industries, while knowledge is the basis for supporting the innovation [79]. The deeper analysis of blockchain transformation and integration in SCM leads to the understanding of knowledge roles in information distribution, known as knowledge sharing (KS). KS is used to facilitate knowledge exchange within a network or chain. Blockchain integration leads the related parties to get the information in real-time, after which it is processed to be knowledge [25]. It is similar to the other skills acquired in developing and managing systems and their utilization in the broader space of SCM. KS concept principally illustrates the individual endeavor in transforming knowledge to other individuals or organizations [80-82]. In this case, the knowledge transferred is in the form of the latest technology, information, and skill shared with the organization involved in the chain [83]. Hence, the interpretation gives a conclusion that blockchain integration in SCM is important for the management of the KS among partners in the chain, leading to the hypotheses below.

Hypotheses 3 (H3): Knowledge sharing is notable and favorable to blockchain adoption.

3-4- The role of Blockchain Adoption, Transparency, and Performance

In the future blockchain technology urgently needs to be implemented, especially in SCM. This technology is still progressing, and if it is well organized, it gives a significant contribution to improving the partner collaborations with other businesses. The aspect of environmental kindness is critical because of the integration of blockchain technology into SCM [84]. Another study shows that blockchain integration improves the performance of business processes, particularly in SC [19]. Besides, transparency is known to be beneficial for the establishment of a business. It is also seen to be carried out in this technology integration and makes the transparency accelerate [85], even though it needs to be adapted in certain parts [76, 86, 87]. The superiority of transparency that can improve the performance, effectiveness, and trust of SCM business processes makes this kind of technology beneficial for the industries.

The process of SC is highly complex as data and information transform rapidly, and the problem appears in the asymmetric distribution of information [88]. Hence, it is expected that blockchain technology contributes to solving the complex problems that arise during the SC process. It is also expected to enhance the effectiveness and performance of SCM while simultaneously increasing the profit and providing possibilities for other businesses [89-91]. Besides, blockchain is trusted in improving the accountability of SCM business processes [17, 19, 26, 30]. Another aspect that is expected substantively from blockchain integration is its transparency in business processes, increasing the trustworthiness of its chain. The superiority of blockchain is also seen in the concept of real-time and historical tracking. This concept is helpful to minimize or even omit the variability of information in SCM [17]. It increases the level of trust and builds coordination in SC. Therefore, the following hypotheses are raised.

Hypothesis 4 (H4): Blockchain adoption has a great impact and gives a positive value to supply chain transparency.

Hypothesis 5 (H5): Blockchain adoption has a great impact and gives a positive value to the supply chain performance.

Hypothesis 6 (H6): Blockchain adoption has a great impact and gives a positive value to blockchain transparency.

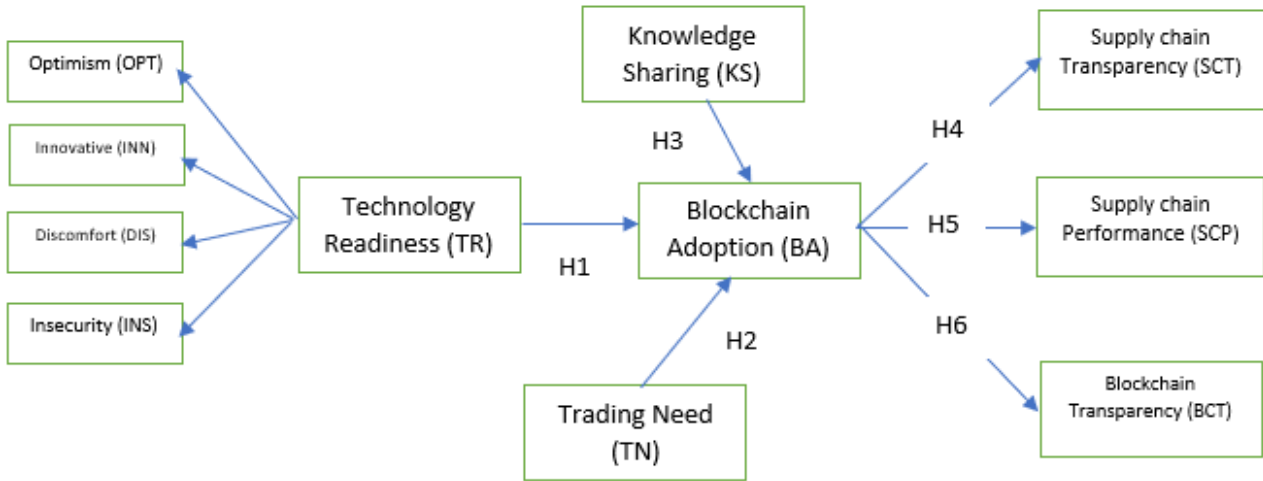


Figure 1. Research model and hypothesis framework

4- Research Method

The present research is conducted to measure the impacts of the process of blockchain technology implementation and integration into SCM using a user benchmark [39]. The data collection process is organized using approaches of the online questionnaire and online survey. The online approach is properly applied not only due to the Covid-19 pandemic but also considering that the survey is directed to know more about the level of the latest technology usage [92-94]. By applying the method, the researcher could go further in detail to discover the facts in the environment supported by the point-to-point data collection from the users [59, 95-97]. To strengthen the theory, the researcher established the principles taken from the related literature, which were then elaborated and adapted taking into account the suitability aspect of this research. Consequently, the executed variables were strengthened for the assessment [95]. Construct variable in this research was a 7-point Likert scale, starting from 1 (strongly disagree) to 7 (strongly agree). The data were taken from Taiwan and Indonesia with the source of blockchain users and SCM in various industries. The surveyed respondents were the users who had a minimum of one year of experience with the blockchain in the field of SCM to guarantee that the collected data were valid and accurate. Out of 322 online-distributed questionnaires, 295 were obtained which seemed to be valid and could be processed to the next step. Accounted in percentage, 55.25% of the respondents were male, 43.05% were in an age range of 26 to 35 years old, and 55.59% were undergraduate. Table 2 displays the demographic characteristics of the respondents.

Table 2. Sample demographic

Characteristics	Frequency	Percent (%)
Characteristics by Gender		
Male	163	55,25
Female	250	84,75
Characteristics by Age		
< 25 years old	63	21,36
26-35 years old	127	43,05
36-45 years old	125	42,37
> 45 years old	98	33,22
Characteristics by Education level		
High school certificate or lower degree	137	46,44
Undergraduate degree	164	55,59
Master or higher degree	112	37,97
Characteristics by Experiences		
> 1 Year	227	76,95
< 1 Year	68	23,05

The single factor test of the Harman concept was used to ensure that no data and information obtained in this study were unbiased. Accordingly, each respondent had to fill out all the questions given carefully. All inquiries were built with a rigorous process. The question items in this study referred to several previous studies, and revisions were made by experts in the field of information technology. A pre-test was undertaken to improve the questionnaire's semantics. Meanwhile, to check for the existence of CMV, Harman's single-factor test was used (Podsakoff and Organ, 1986), which shows validity when a single factor can reflect most of the covariance of variables. Based on the results test the component failed to explain 50% of the variation, that is implying the questionnaire did not have CMV. Figure 2 describes the flowchart of the research method.

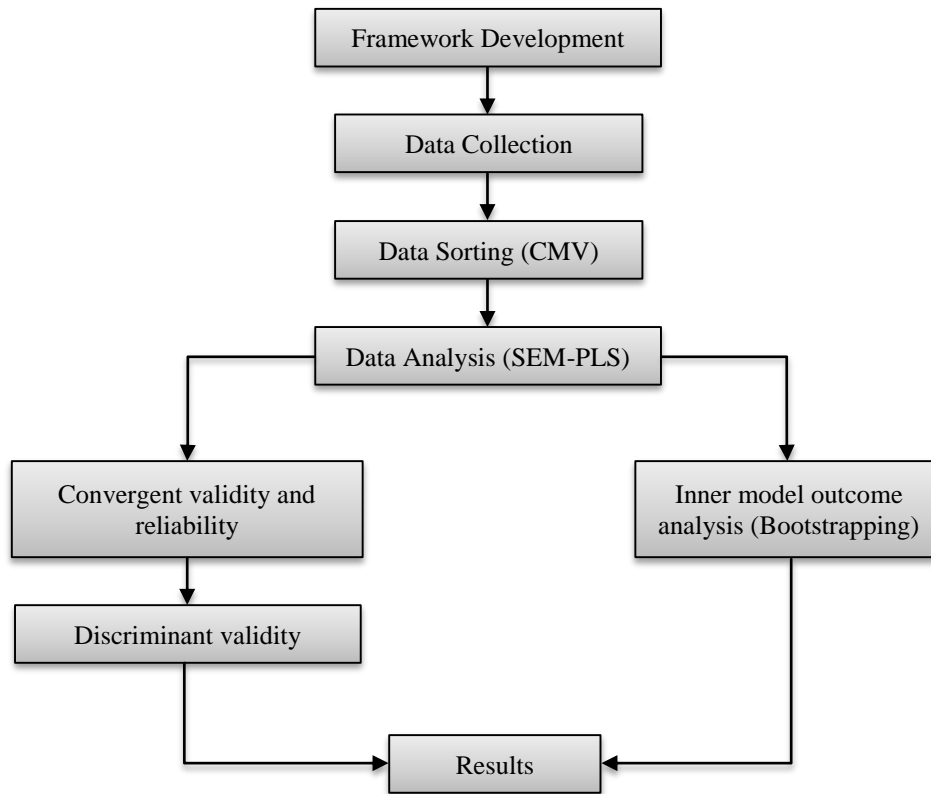


Figure 2. Flowchart of research methodology

5- Data Analysis and Result

Partial Least Square (PLS) is a technique operated to analyze data. PLS is the concept that applies and follows the pattern of Structural Equation Modelling (SEM). The implemented software working for computation in the steps of data analysis is SmartPLS Versi 2.0. The collaboration of PLS and SEM is known then as PLS-SEM. Ringle et al. [66] give an understanding of its usage in their definition of PLS-SEM, which is a method to validate the established variable construct. This technique is also used to review the results of the hypotheses proposed [67, 68]. PLS-SEM is equipped with a mechanism to refine the method of linear regression and double regression. The concept offered by PLS-SEM accelerates the quality and quantity of the research in the broadest field. Besides, PLS-SEM is still capable of analyzing little data, using formative variable construct and conducting reflective construct simultaneously [69-71]. Table 3 presents measurement items of constructs used in this research are presented in detail.

Table 3. Measurement items of constructs

Scoring from “strongly disagree” to “strongly agree” on a seven-point scale	
Technology Readiness - Optimism	
OPT1	Blockchain technology makes me more efficient in my occupation.
OPT2	Blockchain technology gives me more freedom of mobility.
OPT3	Learning about blockchain technology can be as rewarding as the technology itself.
Technology Readiness - Innovative	
INN1	Figure out new high-tech products and services without any help
INN2	Have fewer problems than others in making technology work
INN3	Keep up with the latest technological development that I am interested in

Technology Readiness - Discomfort (reverse scored)	
DIS1	Manual for a high-tech product or service is hardly written in plain language.
DIS2	Technical support lines are not helpful because they don't explain things in terms that I understand.
DIS3	When getting technical support, I feel as if being taken advantage of by someone who knows more than me.
Technology Readiness - Insecurity (reverse scored)	
INS1	I worry that the information I send over the Internet may be seen.
INS2	It's not safe to do any kind of financial business online.
INS3	It's not safe to give the vendor financial information.
Blockchain Adoption (BA)	
BA1	My company invests resources in blockchain-enabled supply chain applications
BA2	Business activities in our company require the use of blockchain technologies.
BA3	Functional areas in my company require the use of blockchain technologies.
Knowledge Sharing (KS)	
KS1	The firm prefers to share know-how innovations and blockchain-enabled supply chain knowledge with supply chain partners.
KS2	The firm prefers to share relevant market knowledge and blockchain-enabled supply chain knowledge with supply chain partners.
KS3	Firm openly shares knowledge on blockchain-enabled supply chain applications with your supply chain partners
Trading Need (TN)	
TN1	The major trading partners of my company encouraged the implementation of blockchain technologies.
TN2	The major trading partners of my company recommended the implementation of blockchain technologies.
TN3	The major trading partners of my company requested the implementation of blockchain technologies
Supply chain transparency (SCT)	
SCT1	Consider to what extent blockchain could improve the following tasks: recording and transferring quantities of assets (e.g., pallets, trailers, containers) as they move between supply chain nodes.
SCT2	Consider to what extent blockchain could improve the following tasks: tracking purchase orders, change orders, receipts, shipment notifications, or other trade-related documents.
SCT3	Consider to what extent blockchain could improve the following tasks: assigning or verifying certifications or certain properties of physical products, such as determining if a food product is organic or fair-trade
Supply chain performance (SCP)	
SCP1	Our supply chain can meet special customer specification requirements.
SCP2	Our supply chain can produce products characterized by numerous features, options, sizes, and colors.
SCP3	Our supply chain can rapidly adjust capacity to accelerate or decelerate production in response to changes in customer demand.
Blockchain Transparency (BCT)	
BCT1	I believe blockchain-enabled supply chain processes would be transparent.
BCT2	I believe supply chain stakeholders would enable me to have a better understanding of how blockchain-enabled supply chain applications work.
BCT3	I believe supply chain stakeholders would provide me with in-depth knowledge of blockchain applications in the supply chain.

Furthermore, the benchmark or threshold rating of this research is according to the concept presented by Fornell and Larcker [68]. The assessment to measure the reliability involves the values of Cronbach's alpha, composite reliability, and AVE. Construct value should be > 0.7 and the value of AVE should be > 0.5. If the value of those constructs is achieved, the variable construct can be classified into the criterion of convergent validity. Table 4 summarizes the obtained values regarded as the indicators of the variable constructs.

Table 4. Convergent validity and reliability analyses

Measurement Item	Factor Loading	AVE	Composite Reliability	Cronbach's Alpha	Communality	Redundancy
BA	0.9175	0.8107	0.9278	0.8831	0.8107	0.0923
	0.8863					
	0.8970					
BCT	0.8372	0.7027	0.8764	0.7892	0.7027	0.4135
	0.8229					
	0.8544					

DIS	0.9339 0.9183	0.8577	0.9234	0.8345	0.8577	0.6986
INN	0.9158 0.9012	0.8254	0.9043	0.7888	0.8254	0.6602
INS	0.9049 0.7544	0.6940	0.8181	0.5747	0.6940	0.4948
KS	0.9109 0.8653 0.9128	0.8039	0.9248	0.8779	0.8039	0.0000
OPT	0.9142 0.9083	0.8303	0.9073	0.7957	0.8303	0.5316
SCP	0.9118 0.8868 0.9300	0.8275	0.9350	0.8956	0.8275	0.5223
SCT	0.8780 0.9370 0.9388	0.8435	0.9417	0.9077	0.8435	0.2461
TN	0.8003 0.8977 0.7608	0.6751	0.8611	0.7616	0.6751	0.0000

Table 5. Discriminant validity

	BA	BCT	DIS	INN	INS	KS	OPT	SCP	SCT	TN
BA1	0.9175	0.7066	0.9339	0.7823	0.6980	0.7410	0.5850	0.7155	0.5039	0.6181
BA2	0.8863	0.7197	0.7560	0.7134	0.9049	0.7743	0.5488	0.7245	0.5141	0.6304
BA3	0.8970	0.6533	0.7436	0.8753	0.6474	0.7285	0.6463	0.7096	0.4540	0.5364
BCT1	0.6645	0.8372	0.5533	0.6787	0.7170	0.6524	0.5039	0.6754	0.7676	0.8977
BCT2	0.5707	0.8229	0.4885	0.7015	0.6019	0.6279	0.3928	0.7159	0.5096	0.5483
BCT3	0.6919	0.8544	0.6701	0.7353	0.6792	0.7999	0.4363	0.8092	0.5537	0.6063
DIS1	0.9175	0.7066	0.9339	0.7823	0.6980	0.7410	0.5850	0.7155	0.5039	0.6181
DIS2	0.7454	0.5579	0.9183	0.5976	0.6278	0.6430	0.5679	0.5756	0.3732	0.5050
INN1	0.8703	0.6639	0.7280	0.9158	0.6447	0.7358	0.5988	0.7160	0.4530	0.5244
INN2	0.7171	0.8726	0.6311	0.9012	0.6589	0.8352	0.4966	0.9300	0.6051	0.6407
INS1	0.8863	0.7197	0.7560	0.7134	0.9049	0.7743	0.5488	0.7245	0.5141	0.6304
INS2	0.4273	0.6049	0.3764	0.4411	0.7544	0.4977	0.3763	0.5025	0.6472	0.6942
KS1	0.7804	0.7222	0.7334	0.7639	0.7213	0.9109	0.5423	0.7885	0.5500	0.5944
KS2	0.7029	0.7739	0.5837	0.7948	0.6761	0.8653	0.4538	0.9118	0.5357	0.5986
KS3	0.7493	0.7458	0.6926	0.7638	0.7183	0.9128	0.5017	0.8868	0.5008	0.5939
OPT1	0.6069	0.4866	0.5990	0.5086	0.5723	0.5093	0.9142	0.4699	0.3882	0.5040
OPT2	0.5926	0.4835	0.5348	0.5950	0.4625	0.5079	0.9083	0.5019	0.3411	0.4447
SCP1	0.7029	0.7739	0.5837	0.7948	0.6761	0.8653	0.4538	0.9118	0.5357	0.5986
SCP2	0.7493	0.7458	0.6926	0.7638	0.7183	0.9128	0.5017	0.8868	0.5008	0.5939
SCP3	0.7171	0.8726	0.6311	0.9012	0.6589	0.8352	0.4966	0.9300	0.6051	0.6407
SCT1	0.4138	0.5698	0.3549	0.4224	0.5685	0.4184	0.3893	0.4321	0.8780	0.7308
SCT2	0.5022	0.7169	0.4379	0.5386	0.6418	0.5654	0.3336	0.5927	0.9370	0.7602
SCT3	0.5676	0.7133	0.5025	0.6097	0.6306	0.6144	0.3857	0.6082	0.9388	0.7715
TN1	0.5152	0.5787	0.5258	0.4270	0.5980	0.4833	0.3892	0.4702	0.5961	0.8003
TN2	0.6645	0.8372	0.5533	0.6787	0.7170	0.6524	0.5039	0.6754	0.7676	0.8977
TN3	0.4063	0.5627	0.4045	0.4201	0.5835	0.4733	0.3724	0.4788	0.6516	0.7608

The value of the path coefficient becomes the standard of PLS-SEM to determine the score of a latent variable. Meanwhile, the percentage of exogenous variables to endogenous variables is determined by the score of R-square (R²). Higher scores represent relatively stronger predictions. Both of the indicators are used to interpret the degree of conformity between the established framework and the collected empirical data. Table 6 and Figure 3 summarize the score of path coefficient, T-statistics, and the hypotheses of this study.

Table 6. Inner model outcome summary

Hypothesis	Path Hypothesis	Path Coefficients	T-Value	Results
H1	TR - BA	0.941***	6.420	Accepted
H2	TN - BA	0.271***	2.652	Accepted
H3	KS - BA	0.272***	2.150	Accepted
H4	BA - SCT	0.546***	8.156	Accepted
H5	BA - SCP	0.796***	9.553	Accepted
H6	BA - BCT	0.771***	5.348	Accepted

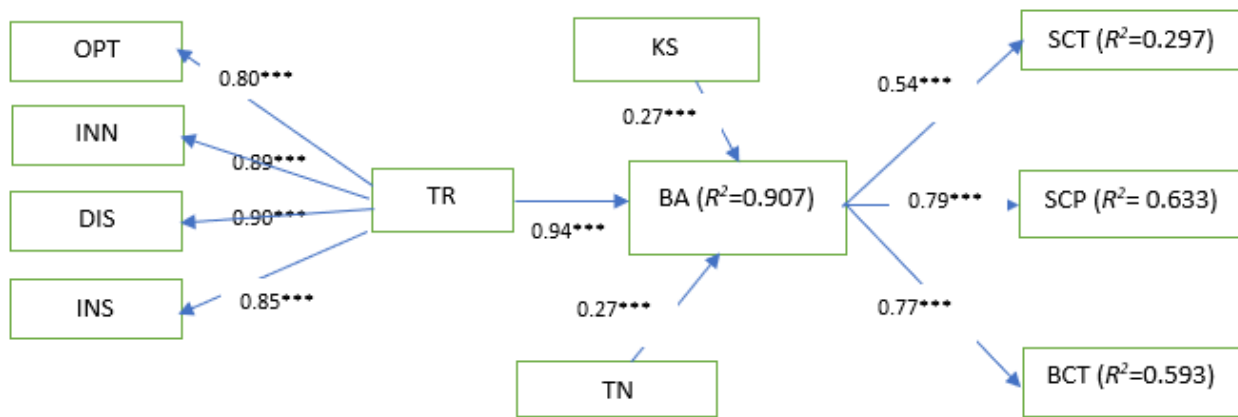


Figure 3. Results of path coefficients and hypothesis testing

The score and the significance of the proposed hypotheses in this research are measured considering the concept presented by Chin [73], which indicates the acceptance or the rejection of hypotheses in PLS-SEM. The bootstrap algorithm is applied as the technique of measurement. The standard of acceptance in bootstrap algorithms is obtained by measuring the score of T-statistics., which should be >1.95. Accordingly, the result of significance is applied as the standard of path coefficient. As proposed by Chin [73], the basic concept of bootstrap is the use of non-parametric models to predict the significance score of empirical research. The results of the computation in this research took the score of the T-statistic into the qualified criterion proposed by Chin [73]. According to Table 3, the six predicted hypotheses had a significant score of T-statistic, and all the hypotheses were accepted.

In hypothesis 1(H1), the technology readiness had a significant and positive value on the blockchain adoption (TR-BA; $\beta = 0.941$; t-value = 6.420). Concerning hypothesis 2 (H2), the trading needs variable had a significant and positive score on blockchain adoption (TN-BA; $\beta = 0.271$; t-value = 2.653). The results obtained for hypothesis 3 (H3) showed that the variable of knowledge sharing had a significant and positive score on blockchain adoption (KS-BA; $\beta = 0.272$; t-value = 2.150). It was also confirmed that hypothesis 4 (H4) related to the blockchain adoption had significance and positive value to supply chain transparency (BA-SCT; $\beta = 0.546$; t-value = 8.256). A similar conclusion was also made for the fifth hypothesis (H5), indicating that blockchain adoption had significance and a positive score on supply chain performance (BA-SCP; $\beta = 0.796$; t-value = 9.553). The significant and positive values were also obtained for the sixth hypothesis (H6) for the blockchain adoption related to blockchain transparency (BA-BCT; $\beta = 0.771$; t-value = 5.348).

6- Research Analysis and Discussion

The study gives a holistic picture of blockchain integration into supply chain management systems. From the academic perspective, the study gives a contribution to the literature of blockchain integration and SCM in driving the rapid enhancement of information and technology related to the influence of SCM and blockchain. Besides, from the managerial aspect, the concept offered by this research is to create a novel change in solving the problems of SCM management, which corresponds to the latest technology developments [4, 98-102]. Meanwhile, the hypothesis of this research has a relevant correlation to the study directed by previous researchers who have confirmed the significant value of the integration of blockchain into SCM. In hypothesis 1 (H1), the technology readiness construct was confirmed to

have a significant relationship with blockchain adoption, showing the optimism of the change to digital transformation that leads to the innovative nature of a company. As shown, discomfort and insecurity of technological changes do not influence the paradigm of using the latest technologies.

The need for encouragement from business partners is a challenge for the companies in adopting blockchain technology as proposed by hypothesis 2 (H2). It happens as the logical consequence of the recent transaction needs. Hence, hypothesis 2 is confirmed in line with other research confirming the high validity of business partner encouragement as an indicator of the integration of the novel technologies [74, 78-79]. Then, the researcher discovered through the third hypothesis that knowledge sharing has become the structured pattern established in the concept of SCM. Integration using blockchain technology gives a great impact on blockchain adoption. Taking the result of hypothesis 4 (H4), the effect of adopting blockchain was positive and significant concerning supply chain transparency, which is consistent with the results of previous studies confirming the implementation of blockchain in improving the quality and transparency of SCM [19, 47, 69].

The preceding research did not explain in detail the influence of adopting blockchain technology on SCM performance, especially in its transparency [29, 103]. This deficiency was accomplished by the present research by focusing on the concrete contribution of blockchain integration to SCM, enriching research on SCM or blockchain as proven by the results of hypotheses 4, 5, and 6. From our in-depth analysis, we found and validated that the integration of blockchain and SCM can have significant contributions. The conclusion correlates to the latest research related to blockchain integration and SCM. The findings show that blockchain integration into SCM can improve the quality of SCM performance while giving transparency to the SCM process and performance, as well as transparency to the process and the performance of its blockchain. The problem of SCM is in its lack of efficiency and the minimum quality of privacy in its transparency [38]. Our hypothesis is valid and influenced significantly. Nonetheless, it should be noted that the scope of this research was limited to Taiwan and Indonesia, and its implementation in other countries might need dissimilar adoption [103, 104].

The results obtained from blockchain integration into SCM and its measured impact contribute to SCM management, especially for the managers to have an in-depth understanding of the knowledge and decision making in the SCM process. This research specifically provides empirical evidence of the relationship between blockchain technology and SCM regarding the level of performance. The literature review of SCM explains that the performance of SCM in business processes is crucial [57, 65] since effective and efficient management is necessary [105]. Our presented research reveals the novelty of the concept and paradigm in the integration of blockchain and SCM, along with the examination and validation of the concept.

The findings reveal that managers should be able to understand the substantive problem and the blockchain integration complexities. It is our invention that technology readiness is a challenge faced by managers in managing their employees' viewpoints and business partners' adoption of blockchain technology. Instead of focusing on the positive or negative perception, it is better to manage the perception of innovation in recent technology development. In addition, encouragement from partners is necessary to improve the effectiveness and quality of the business process, while the encouragement of knowledge helps to come up with the challenge during the SCM process of adopting blockchain technology [60, 65, 97, 106]. Another challenge confronted by the managers is the cross-country business process that has to be classified based on the targeted country or business partner.

To achieve a run-well implementation and integration of blockchain and SCM, managerial patterns should be well mastered. The present research establishes a strong correlation between those two technologies concerning the concept of transparency. Adopting blockchain technology and integrating SCM influences SCM performance. As a consequence, the decision-makers of a company should understand the concept of transparency from both technologies. Several references analyzing the transparency of blockchain and SCM found a significant refinement of SCM in its visibility and accountability [17, 19, 26]. The operational performance of the companies could be potentially enhanced by deepening the managers' understanding of the importance of technology integration.

This study theoretically contributes to the knowledge of SCM by clarifying the complexity of SCM performance, the disruption of SCM, and the dynamic and role of the latest technologies in the SCM industry. This study also clarifies the concept and the performance of blockchain technology in SCM while describing the establishing framework, and validating and analyzing them using the concept of statistics. The analysis of the research proves that the adoption and the integration of blockchain into SCM support the performance of SCM effectively. Additionally, this study empirically confirmed that the adoption of blockchain technology significantly influences the performance of SCM and blockchain. Hence, the framework enables us to confirm that the performance of blockchain and SCM is measurable and predictable.

Our consideration for further research is to involve other important variables, such as accountability and satisfaction, in the framework of blockchain [30] to broaden the scope of the framework. The industries of SCM analyzed in this research are too specific; thus, future studies can analyze industries from other sectors. Our recent research contributes to the knowledge of technology integration in SCM, and our established framework integrates the substantive variables in empirical assessment by adding the variables of technology readiness to give novelty to the knowledge of assessing blockchain adoption. Another topic for future research could be innovation in the logistics process [65].

7- Conclusion

The players in the supply chain industry urgently need to integrate blockchain technologies into supply chain management. The contradiction created during the process of the conventional-based supply chain is detrimental to the users of the supply chain. The invention of blockchain technology builds novelty in the paradigm of supply chain industries. The concept offered by blockchain technology provides solutions from any aspect, such as immutability, decentralization, openness, and productivity. Apart from its capability to enhance the performance, it is also capable of making reliable processes in the supply chain, doing real-time tracking, and maintaining the process of transparency.

The study shows the outcomes and effects of blockchain technology integration into SCM empirically. This study is expected to enhance the knowledge and enrich the reference for future researchers. In addition, the established framework in this study comes from the integration of technology readiness theory and the concept of blockchain adoption. The analysis obtains a significant and positive value since it empirically proves that customer needs and knowledge transfer are factors that encourage the adoption of blockchain technology. It is also concluded that transparency in both technologies is crucial to the outcome of blockchain adoption and has become the prominent antecedent to the refinement of SCM performance. It correlates with the previous research confirming the advantages of blockchain technology in SCM performance and its managerial and theoretical values. These values lead to the improvement of company competitiveness and the performance of SCM. However, to ensure sustainable advantages, knowledge of technology integration has to be continuously strengthened. From the theoretical perspective, this research proves that blockchain technology empirically enables users to strengthen the performance of SCM, providing another viewpoint of knowledge in this digital era.

8- Declarations

8-1- Author Contributions

Conceptualization, A.R. and T.H.; methodology, A.M.A.; software, K.H.A.; validation, T.H., A.R. and A.M.A.; formal analysis, T.H.; investigation, T.H.; resources, A.R.; data curation, A.M.A.; writing original draft preparation, T.H.; writing—review and editing, A.R.; visualization, K.H.A.; supervision, A.R.; project administration, A.R.; funding acquisition, A.R. All authors have read and agreed to the published version of the manuscript.

8-2- Data Availability Statement

The data presented in this study are available on request from the corresponding author.

8-3- Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

8-4- Institutional Review Board Statement

Ethical review and approval was not required for this study on human participants in accordance with the local legislation and institutional requirements.

8-5- Informed Consent Statement

Written informed consent from the patients/participants was not required to participate in this study in accordance with the national legislation and the institutional requirements.

8-6- Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies have been completely observed by the authors.

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