To Study Influence of Blockchain Technology, Supply Chain Mapping, Integration on Supply Chain Sustainability

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Abstract

Motivation of this research study reflect better understanding how supply chain sustainability in Pakistan's supply chain industry is influenced by aspects including block chain technology, followed by integration and mapping. The illustration is 384, with 5% error margin and a 95% confidence level. The target industry for this campaign was determined to be the supply chain sector. Out of 500 surveys disseminated, 384 valid replies were received from the target supply chain sector using a Google survey form that used the PLS-SEM model for work. We employ PLS-SEM sampling technique to assess the latent variables' power and how well they can account for the target structures. The main reason (PLS-SEM) is utilized is because it can estimate very complex models with a small amount of data. The results support each of the following direct hypotheses: supply chain integration is negatively impacted by block chain technologies, supply chain mapping is negatively impacted by block chain technologies, integration has a significant impact on supply chain sustainability, and supply chain mapping has a significant impact on sustainability. In order to provide a comprehensive understanding of supply chain sustainability across industries or nations, it is advised that additional variables be included in future research. This study primarily focused on blockchain technologies (BT), supply chain integration, and mapping on supply chain sustainability. This research enhances the work environment by examining the effects of blockchain technologies (BT) and supply chain sustainability within the framework of Pakistani supply chain businesses.

Keywords*: Supply Chain Sustainability, Resilience and Integration.*

Introduction

The lack of tangibility in supply chain networks adversely affects firms' capacity to promptly address supply chain disturbances. As a result of the ongoing COVID-19 pandemic, corporate supply chain networks are diligently striving to address the repercussions and are exerting considerable efforts to safeguard the well-being of their component and raw material suppliers. These measures are aimed at maintaining the smooth functioning of their supply chains in accordance with their intended operations. According to Mubarik, Naghavi, et al. (2021) and Choi et al. (2020), The absence of comprehensive supply chain mapping and insufficient supply chain integration, conversely, results in the unavailability of crucial information. Consequently, the response to the problems presented by the COVID-19 pandemic has become disorderly. As a consequence, there was an enhanced and responsive response to unanticipated disruptions. To attain supply chain visibility, transparency, and sustainability, it necessitates the establishment of a proficient and organised supply chain (Naghavi, 2021). The practise of supply chain mapping has emerged as an essential element within contemporary corporate operations, with organisations employing it as a means to achieve sustainability, integration, and visibility within their supply chains. In the contemporary business landscape, it is imperative for organisations to ensure the generation of favourable results. Environmental uncertainties arise due to various factors, including changes in consumer tastes, the impact of globalisation, competitive market conditions, and a heightened emphasis on innovation (Syed et al., 2020; Yayla and Hu, 2012).

In this particular scenario, enterprises respond to uncertainties in the environment by implementing various strategies and philosophies with the aim of enhancing their competitiveness and anticipated performance level (Liu et al., 2019; McLaren et al., 2011; Teo & Pian, 2003). Consequently, the occurrence of disruptions within the supply chain has the potential to hinder meticulously planned plans, consequently affecting the continuity of a company (Baghersad & Zobel, 2021; Xu et al., 2016). Supply chain disruptions have the potential to cease an organization's operations and services due to their impact on the quality, cost, processing, sourcing, and delivery of goods and services (Chopra & Sodhi, 2014; Downes & Nunes, 2013; Pereira, 2009; Tomlin, 2006; Tönnissen & Teuteberg, 2020; Xue et al., 2018). Disruptions may arise from extraordinary events such as pandemics, cyberattacks, natural disasters, or product and service-related concerns (Min, 2019; Nguyen & Nof, 2019). In recent years, the epidemic has exerted a significant impact on both the domestic economy and the

global economy. The international community has acknowledged the importance of ensuring the security of supply networks and sectors. Efforts have been undertaken by researchers to optimise the elasticity of the energy supply. Moreover, extensive research has been conducted across various sectors, encompassing food, dairy, agriculture, the hotel industry, healthcare services, smart cities, and the assessment of elastic efficiency.

The examination of digital technologies in the context of supply chain resilience has also been a subject of scholarly inquiry. The advent of Industry 4.0 has brought about a significant transformation in the industrial supply chain domain. Since the onset of the COVID-19 pandemic, various businesses have been integrating novel technological advancements into their operational frameworks. These include the adoption of the Internet of Things (IoT), cloud computing, data analytics, Lean 4.0 (L4.0), artificial intelligence, machine-to-machine (M2M) communication, and cyber-physical systems (CPS). The disruption of supply chains, attributed to precautionary measures implemented by governments worldwide, has been identified as a contributing factor to the breakdown in global trade. This disruption has had significant repercussions for both domestic and multinational corporations. The emergence of the fourth industrial revolution followed the advent of internet technologies. The implementation of strategy I 4 enables the use of L4 as a means to mitigate expenses linked to workforce, resources, machinery, and project durations, with the ultimate goal of waste reduction. The technology industry predominantly comprises small and medium-sized firms (SMEs) with the objective of fostering the sustainable development of the country.

Similarly, small and medium-sized firms (SMEs) within large corporations have been contemplating the transition of their operations from Level 4.0 to Industry 4.0 oriented. The COVID-19 pandemic has had a significant influence on supply chains, making it one of the most affected areas in the field of business (Jalees et al., 2024). States that experienced disruptions and cessation of supply networks have subsequently implemented measures to address the issue, resulting in heightened financial losses for competitive firms. Numerous studies have demonstrated that the COVID-19 pandemic has exerted an adverse influence on supply networks on a global scale. The rise in globalization-related company failures, which have had a negative impact on various types of enterprises, can be attributed to the government's implementation of precautionary measures in response to the epidemic.

Supply chains with negative dosages were first identified by pandemic, and they quickly expanded to many parts of the world, posing a serious threat. Global supply networks are being undermined by the highly hazardous Covid-19 virus (Choi 2020; Ivanov 2020a). Thus, maintaining excellent health requires a diet that is both balanced and eats a sufficient amount of food. However, as the world's population has grown, more attempts and technologies have been made to feed the populace. Consequently, it was critical to boost sustainable agricultural production in order to enhance the global supply chain and guarantee that everyone had adequate access to food. Concerns have been raised about food insecurity, which by the end of 2020 was projected to affect 265 million people due to a pandemic-related economic downturn. Sadly, the pandemic threatened the sustainable development objectives, particularly the two that depend on food security: eradicating hunger and poverty. It also severely damaged these aspirations, particularly in rich nations. Organizations are now more competitive as a result of globalization (Mishra et al. 2016; Seo and Mason 2018).

Businesses that actively participate in the globalization process have an advantage over other businesses in terms of technology use, financial investments, and skilled management. (Chen, Preston & Swink 2015; Kamalahmadi and Mellat Parast 2016; Shangquan 2000). Globalization does, however, present threats to corporations in addition to providing opportunities for economic development (Chopra and Sodhi, 2004). Thus, under the moderating influence of organizational flexibility, the case study we examined evaluated the relationship between data analytics skills, supply chain resilience, and competitive advantages. Nonetheless, a lot of businesses gather data from supply networks to learn about possible hazards and their long-term consequences on the chains (Fan et al. 2016). Applications have increased in a few industries, including banking systems, insurance, travel, healthcare, e-commerce, logistics, and content distribution (Jamil et al., 2024).

Supply chains had to adjust to the new social structure that governed social and economic segregation, closures, and growing restrictions on social and economic contact as COVID-19 evolved. Transportation and the global economy were being impacted by the limits put in place to stop the spread of the illness. Due to the total destruction of supply networks caused by COVID 19, routine activities were negatively impacted globally and trade suffered as a result. A few workers were unavailable and deliveries were delayed as a result of the disturbance (Rashid

et al., 2024). Even so, supply chain managers are aware of the raw materials needed to complete the business's operating cycle.

Problem Statement

The first barrier of study illustrates that it was based upon single country focus. Therefore, study indicates Malaysian firms data for analyzing how the blockchain technology had affected supply chain mapping and the supply chain sustainability. Therefore, innovative development & technology business at other places might lack similar business processes as Malaysian organizations poses. Therefore, a cross-country analysis might give some in-depth analysis. Secondly, uncertain environmental issues and the capabilities required for strengthening ACO, SCR and the design of SCR due changing technology regulations and use of poor case study usage. Also the lacking of operational performance and the design of SCR. Thirdly, COVID 19 pandemic caused trouble restricting business operations leading to lack of good decision making. Solution could be use of survey over long period of time. Larger survey to be conducted over large area of population, plus the usage of good research techniques (quantitative / qualitative), lack of comparative studies. Suggestions to handle the disruptive events, contingency planning would help reduce these errors and would help solve matters positively.

Objectives

- To address the limitation of the single-country focus, the first objective of this problem statement is to conduct a comprehensive cross-country analysis research of growing affect of Block chain Technology (BCT) on supply chain (SC) mapping & sustainability.
- To develop strategies for dynamically adapting to uncertain environmental issues and changing technology regulations.
- To focuses on improving decision-making processes, especially during unprecedented occurences, therefore COVID-19 pandemic.

Literature Review and Theory Development

Supply Chain Sustainability (SCS)

There is currently a heightened requirement for the examination and incorporation of supply chain (SC) practises and systems. The integration of business, social, and ecological indicators is facilitated in the domain of supply chain management through the utilisation of the triple bottom line framework, which is a fundamental component of the sustainability concept (Ahmed et al.,

2019; Kusi-Sarpong et al., 2021; Seuring et al., 2008). One of the primary challenges that must be addressed in order to achieve sustainability in SC is the need to ensure that the goods, services, and operations within the supply chain adhere to certain sustainable certifications and standards (Grimm et al., 2016; Khan et al., 2021; Kusi-Sarpong et al., 2019).

The implementation of supply chain management is necessary in order to effectively monitor and promote sustainability at both the local and global levels. Irrespective of the sequencing of social obligations and ecological and environmental actions, it is the operations of SC that exert the greatest influence. Distributed ledger technology, also known as blockchain technology, has the potential to significantly influence sustainable supply chain practises, distinguishing itself from other contemporary digital technological advancements. Businesses globally are currently focusing on enhancing their financial, social, and environmental performance, driven by the growing demand from their partners (Elkington, 1998). The examination of sustainable processes through empirical and analytical study has encompassed various domains, including the evaluation of technology choices, the management of inventories, the establishment of reverse supply chains, the development of innovative product designs, the design of supply networks, and the practise of remanufacturing (Aziz et al., 2024).

Business Supply Chain Disruptions

Supply chain managers encounter novel problems, necessitating the establishment of a robust, productive, and streamlined network capable of withstanding disturbances within the supply chain. This is according to writers like Fehimnia et al. It must, yet, also be sustainable. Natural disasters, such as earthquakes, tsunamis, and inclement weather, as well as human activity, are to blame for these disruptions. Because of this, the authors also noted that when dealing with unforeseen disruption, supply chain groups frequently stray from their sustainability goals. Numerous writers, including Sureeyatanapas, Waleekhajornlert, Arunyanart, and Niyamosoth, concurred that supply chain disruptions are becoming more widespread among multinational corporations.

But since the Covid-19 epidemic broke out, the world has been facing extreme weather, and supply systems have had to change to fit this new, confined environment (Rashid et al., 2023). Thus, there is a global lack of necessities and luxury items. These incidents compelled businesses to promote supply chain logistics and change management, alerting them to the adjustments that

would be required should disruptive incidents of the same nature recur. Some experts advise businesses to plan out their supply networks thoroughly in order to anticipate and assess supply-side interruptions (Si et al., 2023). Hence, it is imperative to consider the potential for supply disruptions in modern supply chain management. It can be assumed that the issue of supplier choice is intricately linked to the danger of interruption. In that instance, it would be unjust to presume that comprehensive information on every criterion or the decision-maker's whole comprehension of the issue are accessible. In general, disruptive phenomena occur seldom but intensely, and they might be interpreted as uncertainties regarding the supply chain system.

A resilient supply chain network can be planned using EDC (estimated disruption cost), according to certain writers. Assume, for instance, that any supplier is prone to interruptions. The responsible person could therefore decide to choose another option without taking sustainability into account, that is, lowering the likelihood of outages. Authors Lim et al. came to the conclusion that overestimating the risk of a disruption is less harmful than underestimating its probability, despite the fact that it can be difficult to evaluate its feasibility (Mari et al., 2014). You may keep a lid on these disruption costs, supply chain expenses, and other costs by using a multi-objective goal planning-based strategy.

Resilience in the Supply Chain

The term resilience initially found its usage within the field of materials science. This concept pertains to the capacity of an individual, system, or organisation to return to its original state following elastic deformation, without experiencing any substantial alterations. The significance of implementing this concept was underscored in the operations management situation due to the volatile market conditions, environmental factors, and the occurrence of human-induced disasters. Resilience in the field of operations management pertains to an organization's ability to effectively adapt to sudden environmental shifts, demonstrating both proactive and reactive responses. The inaugural study on supply chain resilience in the United Kingdom and Europe was initiated following the occurrence of the foot and mouth disease outbreak in early 2001 and the transportation interruptions resulting from petrol riots in 2000. This study investigated the existing body of knowledge regarding supply chain vulnerabilities within the UK industry. The findings indicate that supply chain vulnerability is a significant concern for businesses.

However, there is a dearth of research on this topic, resulting in limited awareness of the issue. Furthermore, it was determined that effectively managing supply chain vulnerability necessitates the implementation of a systematic approach or methodology (Zaman et al., 2023). Christopher and Peck constructed the initial resilient supply chain model in light of the aforementioned empirical evidence. The authors of this study offer four primary solutions aimed at enhancing supply chain resilience.

1. Enhancing the resilience of a system can be achieved proactively, prior to the occurrence of any disruptive event.
2. The identification and management of risks necessitate extensive collaboration among stakeholders.
3. The ability to swiftly respond to unforeseen events necessitates the presence of agility.
4. The establishment of a risk management culture holds significant importance.

Secondary considerations that were considered included characteristics such as speed, visibility, redundancy, efficiency, agility, availability, and flexibility. The implementation of effective contingency planning protocols is of utmost importance due to the fact that nearly all supply chains experience disruptions of varying degrees and natures. However, not every consequence or risk is predictable. In a similar vein, in the event that there is a disruption in the flow of goods or information, quick action is required to minimize losses. In order to combat the consequences and preserve their competitiveness, businesses must develop both proactive and reactive strategies. Only then will they be able to develop the adaptive capacities necessary to respond to disasters more effectively.

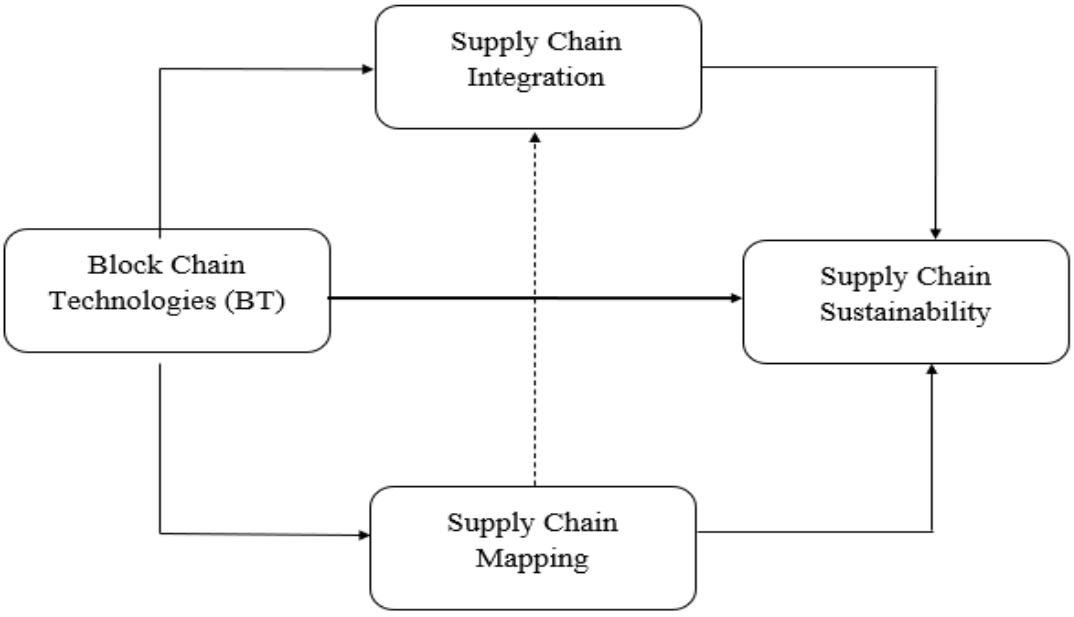
The importance of information in running a resilient and sustainable PFSC

Kot emphasizes that it is impractical to share information with each supply chain member in an effort to improve the system's absorbency and coordination. Information sharing on subjects like "demand forecast information" could improve order fulfillment process efficiency. However, the value of information varies based on its attributes, including completeness, timeliness, and quality, and is impacted by contextual supply chain factors. In the absence of a crisis, supply chain models may treat customer demand as exogenous. On the other hand, PFSC and the semiconductor industry are two instances of how supply chain volatility and consumer demand interact through product availability during times of crisis.

When supply chain instability and consumer reaction work together to reduce demand (after the outbreak), this phenomenon is referred to as endogenous demand. Reduced output and prolonged shortages further diminish demand. Information reflecting endogenous demand will not, or will profit from it very little, in the supply chain decision-making process (Khan, Imran Zaman, et al., 2023). The inventory management system is greatly influenced by the quality of information. Therefore, it is expected that the recognition of existing feedback loops would aid in the examination of dominant feedback loop dynamics and the control of information distribution regarding internal demand. By using efficient strategies to counteract the impact of strong feedback loops, the adverse outcomes resulting from internal demand would be significantly minimized.

Conceptual Framework and Hypothesis Development

Figure 1



Block Chain Technologies (BT) and Supply Chain Sustainability

Moreover, the importance of data security is evident in this particular context. The approval of SC members is required to modify data, so enabling BT to prevent the unjust accumulation of personal assets by immoral associations, governments, and other entities. Furthermore, it is within the purview of BT to prohibit individuals who engage in dishonest behaviour from taking part in its activities and to hold them accountable for their misdeeds, both on an individual level

and in terms of their impact on society (Elias Mota et al., 2020; Mubarik, Naghavi, et al., 2021; Saberi et al., 2019). BT's traceability protocols enhance sustainability by offering heightened guarantees for human rights and fair and secure work environments (Khan, Zaman, et al., 2023).

H1. Block Chain Technologies (BT) positively influences Supply Chain Sustainability.

Block Chain Technologies (BT) and Supply Chain Integration

Previous research has acknowledged the correlation between supply chain management (SCM) and blockchain technology in established domains of SCM, including supply chain distribution, intelligent transportation methods, item traceability, and measures to combat counterfeiting (Queiroz et al., 2019). In contrast to other conventional subjects within supply chain management (SCM) such as quality, procurement, contract lifecycle management (CLM), production/parcel size, vehicle routing challenges, network modelling, inventory, and warehouse management, there has been relatively limited research conducted on the integration of SCM or blockchain technology (ul Haque et al., 2024). The major purpose of integrating supply chain management (SCM) with blockchain technology is to facilitate knowledge gap planning. This objective primarily involves using the latest technical breakthroughs in SCM integration, as discussed by Ali et al. (2021) and Denyer & Tranfield (2009).

H2. Block Chain Technologies (BT) positively influences Supply Chain Integration.

Block Chain Technologies (BT) and Supply Chain Mapping

According to Cottrill (2018) and Mahmood & Mubarik (2020), BT is believed to offer security, authorization, authenticity authentication, and data accessibility for the company's SC. Prior research indicates that BT is a mutual ledger that documents the history of exchanges and transactions, whether or not they involve money, and that, once recorded, cannot be altered (Zelbst et al., 2019).

There will be a mutual record when SC uses BT. A distinct unit, known as a block, is generated for every transaction conducted by participants inside the SC network. The exchanges among the SC partners are interrelated and collectively prohibited, with the SC retaining the recordings indefinitely. In the event of any modifications to the data, the members of the SC will possess the capability to detect such alterations due to the presence of a mapping system associated with

each transaction (IBM, 2018; Mubarik, Kusi-Sarpong, et al., 2021; Mubarik, Naghavi, et al., 2021). On the other hand, handwritten documents typically indicate a cessation in the process of data input. When Radio Frequency Identification (RFID) is integrated with the Internet of Things (IoT), it provides a mapping mechanism that facilitates the efficient input of data into blocks. The good impact of this technology on digitally mapping the supply chain and its potential for enhancing supply chain traceability, transparency, and management has been highlighted by Ali et al. (2021) and Srivastava (2010).

H3. Block Chain Technologies (BT) positively influences Supply Chain Mapping.

Supply Chain Integration and Supply Chain Sustainability

SC sustainable practices are made possible through encouragement from both internal and external sources (Gimenez & Tachizawa, 2012). The activities that help organizations achieve sustainability are referred to as these facilitators. One of the most crucial operational drills in businesses is SCI. Zhang (2016), among others. In order to maintain high standards and foster strategic alliances, it is imperative for organisations to incorporate suppliers into their operational procedures, encompassing the exchange of vital information and involving suppliers in programme design and product development enhancements (Li et al., 2005; Mubarik, Naghavi, et al., 2021).

According to Kang et al. (2018), integrated alliances play a crucial role in facilitating the establishment of strategic ties and the maintenance of long-lasting, systematic partnerships with important suppliers. This is achieved through the cultivation of a cooperative culture and the development of mutual trust. Businesses are being pushed to develop strategies that include suppliers into their sustainable operations due to the growing significance of their roles. These organizations become more well-known for facilitating sustainable management practices because to SCI (Paulraj, 2011).

H4. Supply Chain Sustainability is positively impacted by Supply Chain Integration.

Supply Chain Mapping and Supply Chain Sustainability

Understanding the broader purpose of SCM is essential before determining the SC mapping. Integrations inside an organisation appear to be the main concept underlying effectively managing the SC (Fabbe-Costes et al., 2020; Mubarik, Bontis, et al., 2021; Ali et al., 2021). Houlihan (1983) provided an early description of the criteria of SC mapping, focusing on the

problems that arise when a firm's capacities are not incorporated into a strategy. The following is the solution to these SCM problems: The entire supply chain, from purchasing supplies from vendors to delivering items to customers, is handled as a single process. Indirect and direct logistical procedures should be dealt with by horizontally integrating them on an even playing field with the SC. Previous research has argued in favour of integrations within the company. However, the inclusion of enterprise collaboration within the scope of supply chain mapping has been promptly recognised, and the study of integration in this context has become a well-explored subject (Ali et al., 2021; Frohlich & Westbrook, 2001).

H5. Supply Chain Mapping positively influences Supply Chain Sustainability.

Research Methodology

Data Gathering and Process

The study's sample consisted of 384 individuals and included a 5% margin of error along with a 95% confidence interval. The study's primary focus was the supply chain industry due to previous customer experience in this field. We specifically designed a Google survey form for the supply chain industries they were targeting in order to gather data. After 500 questionnaires were distributed and 384 were returned by the enumerators, a sufficient response rate was attained.

Common Method Bias

Variations in survey results caused by the study instrument are referred to as common method bias (Podsakoff et al., 2003). The study followed the prescribed procedure to lessen the possibility of typical method biases. This required changing the measurements for customer satisfaction and high-quality service as well as creating the theoretical underpinnings for the conceptual framework. The validity and reliability of the questionnaire were additionally verified with the use of the present data set (Podsakoff et al., 2003).

Design of Questionnaire

The questionnaire for the study is divided into two pieces. The first stage was to obtain demographic data that was scaled numerically. The second section, which concentrated on the primary study, consisted of twelve items and four variables with ratings ranging from strongly disagree to strongly agree on a five-point Likert scale.

Scales and Measurements

Every construct used in the study was derived from past research. Table 01 discloses the origins of the structures as well as the quantity of components utilised. As an Appendix, the whole questionnaire is also included.

Table 01

Questionnaires Summary

	References	*Items*
Supply Chain Sustainability	*(Pagell, M., & Wu, Z. 2009)*	3
Block Chain Technologies	*(Zheng et al., 2017)*	3
Supply Chain Mapping	*(Garcia et al., 2021)*	3
Supply Chain Integration	*(Lambert, D. M., & Cooper, M. C., 2000)*	3

Respondents' Characteristics

500 questionnaires were delivered by pre-selected enumerators during their visit to the supply chain industry, and 384 of those were returned completed. Table 2 providing a summary of the respondents' demographics.

Out of the total sample size of 384 participants, it was found that 86.8% were male and 13.2% were female. Among the participants, 1.2% were found to be over the age of 35, while 2.6% fell within the age range of 16 to 20. The majority of respondents, comprising 36.8%, were aged between 21 and 25. Additionally, 28.9% of participants were between the ages of 26 and 30, while 18.4% fell within the age range of 31 to 35.

Table 02

Respondents' profile

	n	**%**
Gender		
Male	33	86.8
Female	5	13.2
Age		
16-20	1	2.6
21-25	14	36.8
26-30	11	28.9
31-35	7	18.4
Above 35	5	13.2

Results And Analysis

Descriptive Analysis

The study's findings in this section, which are compiled in Table 3, examined internal consistency and convergent validity. Additional evidence that the constructs meet convergent validity standards is provided by the results, which indicate that all composite values and AVE values are higher than 0.730 and 0.652, respectively (Sarstedt et al., 2019).

Discriminant Validity

The criteria put forward by Fornell and Larcker (1981) were used in the study to assess discriminant validity. Table 4 presents the results, which indicate that the square root of the AVE values was higher than the values of the Pearson correlation. This suggests that the conceptions used in the investigation are unique and distinct (Fornell and Larcker, 1981).

For the investigation, five direct hypotheses were created. Bootstrapping was used to test these theories. The measurement and structural models are displayed in Figures 2 and 3, respectively. All of the direct hypotheses are supported by the findings: (1) Supply Chain Sustainability is significantly impacted by Block Chain Technologies ($\beta = 0.258$, $t = 5.429$, $p > 0.000$); (2) Supply Chain Integration is significantly impacted by Block Chain Technologies ($\beta = 0.617$, $t = 13.744$, $p > 0.000$); (3) Block Chain Technologies significantly impacted by Supply Chain Mapping ($\beta = 0.671$, $t = 17.288$, $p > 0.000$); (4) Supply Chain Sustainability is significantly influenced by Supply Chain Integration. ($\beta = 0.531$, $t = 11.762$, $p > 0.000$); and (5) Supply Chain Mapping significantly impacted by Block Chain Technologies (β 0.126, t 3.614, $p > 0.000$).

Conclusion

Blockchain technologies (BT) have been found to have a favorable influence on the sustainability of supply chains, as demonstrated by the acceptance of H1. According to existing literature, it has been indicated that Blockchain Technology (BT) has the potential to successfully deter individuals from engaging in dishonest conduct and hold them accountable for both societal and personal transgressions (Mubarik, Naghavi, et al., 2021; Elias Mota et al., 2020; Saberi et al., 2019). Blockchain technology has the potential to enhance the sustainability of fair work practices through its capacity to give traceability. Workers should also possess the information necessary to answer questions from clients in a suitable manner. Skilled employees who record customer transactions are essential to ensuring safe and error-free transactions.

The acceptance of H2 has also been demonstrated, indicating a correlation. Existing supply chain management (SCM) practises can be utilised to enable the integration of blockchain technology, as evidenced by research findings, including intelligent transportation methods, product traceability, anti-counterfeiting measures, and SCM distribution (Queiroz et al., 2019). Nevertheless, the exploration of the amalgamation between supply chain management (SCM) and blockchain technology remains confined to traditional SCM domains, including but not limited to inventory management, warehouse management, network modelling, quality control, procurement, customer relationship management, and production/parcel sizing. The main objective of integrating supply chain management (SCM) with blockchain technology is to improve gap planning by using advanced technical advancements (Ali et al., 2021; Denyer & Tranfield, 2009).

Table 03

Descriptive analysis

	Cronbach's Alpha	***Composite Reliability***	***AVE***
Block Chain Technologies	0.779	0.782	0.695
Supply Chain Integration	0.770	0.773	0.685
Supply Chain Mapping	0.730	0.731	0.652
Supply Chain Sustainability	0.744	0.777	0.666

Table 04

Discriminant validity

	Block Chain Technologies	***Supply Chain Integration***	***Supply Chain Mapping***	***Supply Chain Sustainability***
Block Chain Technologies				
Supply Chain Integration	0.971			
Supply Chain Mapping	0.888	0.815		
Supply Chain Sustainability	0.961	1.051	0.849	

Regarding hypothesis H3, Cottril (2018) and Mahmood and Mubarik (2020) assert that BT is perceived as a means of authorizing and facilitating access to data within a company's supply chain. Blockchain technology (BT) plays a pivotal role as a ledger system in documenting the chronology of transactions, which attain an irreversible status upon completion (Zelbst et al.,

2019). The integrity of supply chain records remains unaltered, and the collective block of modifications for each partner in the supply chain is interconnected and secured. One plausible concern related to data manipulation pertains to its repercussions on the diverse stakeholders engaged in the supply chain. As a result, it is necessary for these stakeholders to provide a thorough documentation of each transaction (IBM, 2018; Mubarik, Kusi-Sarpong, et al., 2021; Mubarik, Naghavi, et al., 2021). The combination of Radio Frequency Identification (RFID) and Internet of Things (IoT) technologies has subsequently enabled the mapping process to efficiently input data into blocks, thereby achieving near real-time capabilities. On the other hand, the utilisation of manual records involves a transient disruption in the procedure of inputting data into designated sections. The previously mentioned data type has a beneficial influence on the digital depiction of the supply chain and assumes a pivotal function in enhancing the traceability, transparency, and management of the supply chain (Ali et al., 2021; Srivasta, 2010).

Table 05

Hypothesis results

Variable	β-Value	Standard deviation (STDEV)	t-statistics	p-values	Decision
Block Chain Technologies -> Supply Chain Integration	0.617	0.045	13.744	0.000	Accepted
Block Chain Technologies -> Supply Chain Mapping	0.671	0.039	17.288	0.000	Accepted
Block Chain Technologies -> Supply Chain Sustainability	0.258	0.047	5.429	0.000	Accepted
Supply Chain Integration -> Supply Chain Sustainability	0.531	0.045	11.762	0.000	Accepted
Supply Chain Mapping -> Supply Chain Integration	0.201	0.050	3.982	0.000	Accepted
Supply Chain Mapping -> Supply Chain Sustainability	0.126	0.035	3.614	0.000	Accepted
				0.000	

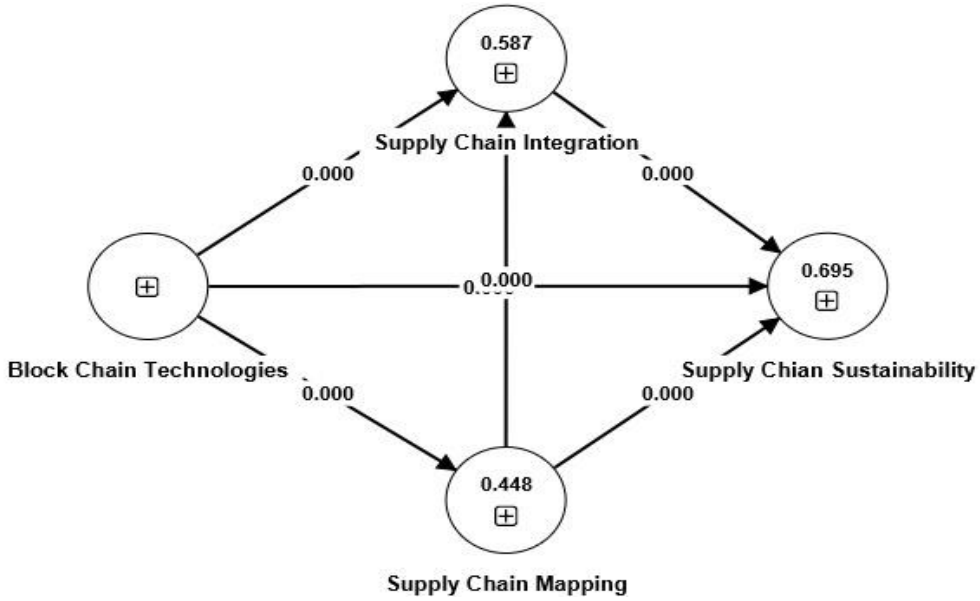
The findings of the study demonstrate a positive and statistically significant relationship between supply chain integration and supply chain sustainability, hence providing support for hypothesis H4. This conclusion is in linked with those made by (Zhang et al, 2016). As a result, immediate

action should be taken to meet integration for quick service. Any customer complaints should be promptly addressed with immediate assistance.

Employees need training to respond promptly, even in stressful work environments. Implementing stress management techniques can help evaluate employees' responsiveness in various situations. Supply chain sector should also provide channels for customer feedback, such as customer service assessment forms, suggestion boxes, email, etc., to measure the responsiveness of their staff.

Figure 02

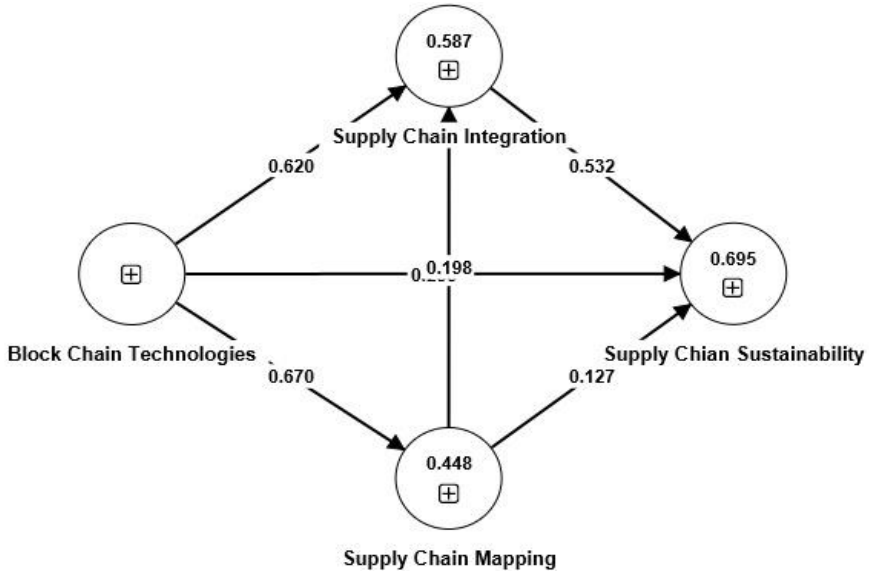
Measurement Model



H5 demonstrates how customer pleasure is greatly impacted by supply chain mapping. It is regarded as the factor that has the greatest bearing on how well supply chain provides service. The alignment between a consumer's expectations and what they receive experience, according to the Business Supply Chain Disruptions (Mari et al., 2014), affects how satisfied they are with the service they receive. Therefore, the results imply that service offered by supply chain typically go above and beyond what customers expect.

Figure 03

Structural model



Conclusion

The production department would provide a strategy characterized by tight coupling, wherein the sales plan's stated value is transformed into a specific target value within the allotted time period. However, in certain instances, the practicality of effectively managing robust and sustainable PFSC may be limited. Pandemics give rise to a relationship between the influx of orders and the specific capability required to remain prominent. Therefore, in such circumstances, implementing restrictions on the transmission of information can contribute to the effective management of a resilient and sustainable public financial sector governance framework. Multiple empirical studies have provided evidence to support the significance of incorporating supply chains in promoting innovation, adaptation, and resilience to enhance organisational performance. To attain a prosperous integration of the supply chain, it is crucial to secure the backing and cooperation of all relevant parties. This entails the ability to effectively strategize, produce, distribute, and exchange pertinent information. It is imperative for every partner to demonstrate unwavering commitment towards cultivating resilience, adaptability, and creativity. Political parties are presently examining substantial consequences in order to tackle the uncertainty and disruptions caused by the COVID-19 pandemic. This study aims to support organizations in enhancing their information technology systems to achieve seamless internal

integration of supply chain management. Organizations proficient in integration management possess the ability to swiftly adjust their supply chains to accommodate flexibility. Supply chain resilience, innovation systems, and supply chain flexibility are all viable approaches for mitigating the effects of supply and demand fluctuations. To ensure the implementation of optimal strategies and the establishment of a robust and adaptable supply chain capable of withstanding disturbances, it is imperative that the innovation system is both valid and reliable. Implementing this strategy is likely to enhance the overall performance of the organization.

In 2001, Professor Sheffi played a pivotal role in the introduction of the notion of sustainable development within the realm of supply chains, thereby instigating scholarly inquiry into the subject of supply chain sustainability. The current study employed survey data obtained from many organisations to examine the interconnectedness between resilience, performance, and sustainability in the realm of supply chain management. The study's findings suggest that the resilience of the supply chain has a positive impact on the sustainability of the economy, society, and environment. Moreover, the aforementioned multitude of elements exerted a positive impact on the operational efficiency of the supply chain. The direct influence of resilience on supply chain performance was shown to be insignificant. However, it was observed that the performance of the supply chain was indirectly affected by supply chain sustainability, which encompasses various dimensions such as social, environmental, and economic factors.

Theoretical Implications

The current research employs the established theoretical framework to examine the effects of disruptions in corporate supply chains, the resilience of supply chains, and the importance of information in efficiently managing sustainable and resilient PFSC (Public Food Service Catering) within the supply chain industry. The primary objective of this study is to not only enhance existing theoretical frameworks but also to identify the various elements that influence supply chain integration, supply chain mapping, and blockchain technology (BT). Furthermore, this research wants to analyze the relationship between each of these factors and the sustainability of the supply chain.

The literature extensively discusses corporate supply chain disruptions, which is a widely recognized model. This model offers a comprehensive framework that considers several issues, encompassing social, economic, and environmental aspects. Enhancing the understanding of the results can be attained by including resilience into the administration of sustainable and resilient

public food supply chains (PFSC), specifically concerning disruptions in corporate supply chains and the significance of information.

Practical and Managerial Implications

The findings of our study hold considerable managerial significance for the effective management of palm fruit sugar (PFSC), particularly within the unique circumstances of the COVID-19 epidemic, when production was temporarily halted. For the supply chain management as a whole, endogenous demand is typically more detrimental than exogenous demand. In order to ensure that products are delivered to their supply chain partners amicably, managers need to establish long-term customer relationship management. Consequently, following the epidemic, decision-making procedures may be improved by a sound, tested planIt is recommended that managers increase their level of autonomy while concurrently enhancing supply chain integration. This approach is crucial for fostering innovation, bolstering supply chain resilience, and facilitating adaptability within the supply chain. By doing so, organizations may effectively navigate unforeseen challenges such as a pandemic and assure sustained firm performance.

The text above presents two conclusions pertaining to management. From the beginning, the authors underscore the need of enhancing the resilience of supply chains. Hence, there exist various publications that address the potential risks associated with interruptions and advocate for the adoption of a risk management culture inside the supply chain network. This approach aims to enhance the resilience and performance of supply chains, thereby ensuring their sustainable development. From an enterprise perspective, supply chains have seen an increase in competitive enterprises. Nowadays, every business is essential to supply chain management operations. Using risk culture to reshape enterprise resilience in businesses has proven to be an effective technique for improving supply chain firms' competitiveness.

Furthermore, the introduction of an intermediary mechanism was observed to impact supply chain performance through supply chain sustainability. This would make it easier to comprehend the reasoning behind whether businesses should increase their resilience or whether doing so will come at a cost. Resilient supply chains are designed to handle highly destructive interruption situations. Many companies believe that these occasions don't require considerable expenditure. According to sustainability's intermediary role, supply chain resilience influences supply chain

performance through sustainability, even in the face of high and fewer interruptions. Organisations must thus place a high value on upgrading and shaping resilience to a strategic understanding level. Therefore, operations can be successful if application in their management is made.

Limitations And Future Recommendations

There will be new and creative research methods available in the near future, such as the ability to analyse the macro and micro environments of businesses. In addition to the current indicators, the organisation would have access to new metrics that would enhance future research, provide supply chain characteristics, and show how their connectedness and direction of environmental effect affect their resilience. The following are a few of the crucial queries: Can SMEs, with their limited resources, have a formalised supply chain? What is the impact of supply chain metrics on small and medium-sized firms (SMEs)?

There are several restrictions on the research, particularly with regard to the population and variable. Based on additional research, it is believed that the present problem involves various factors. Consequently, it is recommended that supply chain risk management and customer relationship management should involve a wider range of stakeholders and consider the functioning of the entire supply chain network.

This research has investigated the interaction between supply chain resilience, supply chain sustainability, and supply chain performance in the supply chain industry, leading to improved research outcomes. To improve the robustness of the study, it is crucial to balance the number of samples and assess sample distribution as sample size increases. Ultimately, additional research on supply chain management and innovative techniques for enhancing the index system, in addition to real-world business scenarios and industry features, may be undertaken.

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Appendix

Construct/Items

Supply Chain Sustainability (Pagell, M., & Wu, Z. 2009)

1. Does your organization collaborate with suppliers to improve sustainability practices?
2. Does your organization have a process for continuous improvement of supply chain sustainability?
3. Does your organization learn from past sustainability challenges to enhance future decision-making?

Block Chain Technologies (Zheng et al, 2017)

1. Do you think block chain can improve supply chain management?
2. Can block chain technology enhance traceability and transparency in complex supply chains?
3. Can block chain help in reducing fraud and counterfeit products within supply chains?

Supply Chain Mapping (Garcia et al., 2021)

1. Are you familiar with the concept of supply chain mapping?
2. Do you ensure the accuracy and reliability of the data used in your supply chain map?
3. Do you ensure that your supply chain map aligns with your organization's strategic goals and objectives?

Supply Chain Integration (Lambert, D. M., & Cooper, M. C., 2000)

1. Does your organization collaborate with its suppliers and customers to share information and resources?
2. How would you assess the alignment of your supply chain goals with those of your suppliers and customers?
3. Are risk management strategies integrated across the supply chain to address disruptions?