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Blockchain Technology for Supply Chain Efficiency in a Selected Business in Guangdong, China

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Abstract: This study investigates the influence of blockchain technology integration on supply chain efficiency, considering demographic factors and organizational perspectives. Through a comprehensive analysis of survey data collected from diverse respondents, including sex distribution, age demographics, and hierarchical positions within organizations, the study explores perceptions of blockchain's significance and its impact on various supply chain functions. Key findings reveal a predominant representation of females and a demographic skewed towards younger age groups, indicating openness to technological advancements like blockchain. While blockchain is recognized for its role in ensuring record immutability and enhancing transparency, skepticism remains regarding its contribution to material management efficiency. Despite moderate improvements observed in inventory and logistics operations, challenges such as errors and delays persist, highlighting opportunities for further enhancement. Interestingly, no significant differences are found in perceptions of blockchain integration across gender and age groups, suggesting a unified understanding of its role in supply chain efficiency. However, variations are observed among hierarchical positions, with executives expressing higher confidence in blockchain's impact. Overall, there is a consistent perception of blockchain's positive influence on supply chain efficiency among all employees, regardless of job roles. The study underscores the need for continued research and exploration to fully harness the potential of blockchain technology in supply chain management. Recommendations include targeted initiatives to address challenges, enhance transparency, and streamline logistics operations, ensuring organizations maximize the benefits of blockchain integration for improved supply chain efficiency and resilience.

Keywords: blockchain technology; supply chain efficiency; a selected business

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1. Introduction

Blockchain technology has grown beyond its initial association with cryptocurrencies, gaining traction in various sectors of the economy due to its potential to streamline processes and enhance efficiency. One of the sectors where blockchain has shown considerable promise is supply chain management. By providing a decentralized and immutable ledger, blockchain technology has been posited to address several key issues in the supply chain, such as traceability, authentication, and the seamless transfer of goods and information.

Guangdong, a province in China known for its vibrant manufacturing industry, stands to benefit immensely from integrating blockchain technology into its supply chain processes. Businesses in the region could achieve better transparency, improve efficiency, and create more robust and reliable supply chains. This potential makes Guangdong an interesting location for investigating the effects of blockchain technology on supply chain efficiency.

This research aims to investigate the correlation between the level of blockchain technology integration and the assessment of supply chain efficiency in a selected business in

Guangdong, China. Through this investigation, the study aims to provide insights into whether a higher level of blockchain integration is associated with better perceived supply chain efficiency. The study will assess the respondent's profile in terms of sex, age, and position in the organization, and gauge their perception of the level of blockchain integration in terms of immutability, transparency, and peer-to-peer consensus.

It will also assess the supply chain efficiency in terms of materials, logistics, services, and information flows. Furthermore, the study aims to identify any significant difference in the assessment of supply chain efficiency and the level of blockchain integration when respondents are grouped according to their profile. Finally, the research seeks to develop a strategic plan based on the findings, potentially enabling businesses to leverage blockchain technology to optimize their supply chain processes.

Given the nascent stage of blockchain integration in supply chains and its immense potential, this study will contribute to the burgeoning body of literature on the subject. Not only will it add empirical evidence to theoretical postulations, but it could also aid businesses in their strategic planning by highlighting the benefits and considerations of blockchain integration in their supply chains.

2. Blockchain Technology in Business

Blockchain technology has gained significant interest in financial technology (FinTech) due to its potential to disrupt established operational frameworks in finance and economy sectors. International institutions like the UN and IMF have been monitoring blockchain advancements, with countries like China, Russia, India, and South Africa researching the technology. The decentralized and permissionless nature of blockchains has the potential to disrupt payment clearing. Global financial institutions, including Goldman Sachs, J.P. Morgan, and UBS, have developed strategies and conducted research on blockchain technology. The R3 blockchain consortium, consisting of over 40 financial institutions, has significantly influenced the industry, with Ping An Bank and China Merchants Bank joining [1].

Blockchain technology has been recognized as a potential game-changer for supply chain management, offering benefits such as transparency, traceability, and security. Specifically, this paper will focus on how it can improve the supply chain efficiency of a selected business in China.

The decentralization principle of blockchain technology endeavors to transition from the traditional end-to-end trust model to a trust-to-trust paradigm. This shift empowers users with full autonomy in making trust-related determinations within network applications, such as online social networks. The phenomenon of decentralization facilitates the establishment of distributed trust and consensus, thereby safeguarding the integrity of transactions conducted among peers in the absence of a centrally trusted third party. Verifiable trust guarantees play a crucial role in facilitating transparent audits, thereby establishing a framework for accountability and transparency within networked systems. The emergence of blockchain technology has garnered significant attention across various industries, including but not limited to transport, energy, insurance, finance, and logistics. This technology has been recognized for its ability to foster transparency and trust in interactions among stakeholders, all while circumventing the need for intermediaries or third-party entities. The issue of trust in cloud-hosted data storage persists as a result of the centralized structure of the Internet. The utilization of blockchain technology offers a range of benefits, including immutability, transparency, and peer-to-peer consensus. These features enable the establishment of a trusted audit of networked systems, while simultaneously empowering network edges with control [2].

The utilization of blockchain technology is currently undergoing a profound transformation within the domains of finance and technology. This innovative technology has the potential to facilitate the integration of the real economy, while simultaneously enhancing governance and public service. China plays a pivotal role in the exploration of a

nascent sharing economy, the establishment of a digital economy industrial ecology, and the enhancement of governance and public service. The concept, structure, technical characteristics, development route, governance, and supervision of Blockchain lack consensus among experts and researchers.

Cryptocurrency, with a particular emphasis on Bitcoin, has garnered substantial attention and recognition within both the industrial and academic spheres. The fundamental technological underpinning of Bitcoin is the blockchain, a transparent and distributed ledger that possesses several key attributes including decentralization, persistence, anonymity, and auditability. The utilization of this technology has the potential to yield cost savings and enhance operational efficiency across diverse sectors, encompassing digital assets, remittance services, and online payment systems. The blockchain technology is characterized by its immutability, which guarantees that transactions remain unaltered and resistant to tampering. This feature makes it suitable for various applications, including smart contracts, public services, Internet of Things (IoT), reputation systems, and security services. The blockchain technology, despite its promising potential, encounters several technical hurdles that need to be addressed. These challenges encompass scalability, selfish mining, privacy vulnerabilities, and the limitations of existing consensus algorithms such as proof of work and proof of stake. The aforementioned challenges necessitate the development of solutions aimed at enhancing the efficiency and security of blockchain technology.

Tapscott and Tapscott propose that blockchain technology has the potential to solve transparency issues in supply chains by providing an immutable and secure record of all transactions, which is publicly available [3]. They further suggest that this level of transparency can facilitate the effective monitoring of supply chains, identifying areas of inefficiency and helping to mitigate the risk of fraud.

Furthermore, Pournader et al. note the potential of blockchain technology to improve traceability in supply chains [4]. Through the use of blockchain, businesses can ensure the provenance and authenticity of their products, which can lead to increased trust among stakeholders and, subsequently, higher efficiencies.

A study highlights the security benefits of blockchain technology in supply chain management [5]. They argue that the decentralized nature of the technology makes it highly resilient to cyber-attacks, which is a growing concern for many businesses.

There has been increasing interest in blockchain technology within China. Guo and Liang note that the Chinese government has shown a positive attitude towards blockchain, recognizing its potential to drive economic growth and innovation [1]. Blockchain has been adopted in several industries, including the food, pharmaceutical, and logistics sectors, resulting in improved efficiencies.

The application of blockchain technology to the supply chain management of selected businesses in China is still a relatively unexplored area, calling for more in-depth studies and practical applications. However, the existing literature suggests that this technology has the potential to greatly enhance the efficiency of supply chains, providing significant benefits for businesses and stakeholders.

3. Concept on Supply Chain Efficiency

The concept of supply chain efficiency is an essential factor that has a profound impact on the performance of businesses across industries [6]. This is particularly important given the complex and global nature of today's supply chains, which require efficient operations to ensure competitive advantage.

Organizational goals require considering the specific network requirements, as assessing efficiency and effectiveness is insufficient for evaluating a single relationship. Successful implementation of collaboration strategies and integration of activity chains depends on factors firms don't have direct ownership or control over. In supply chain management, efficiency and effectiveness are paramount objectives. Efficiency is achieved

through on-time production and robust logistic supplier networks, while effectiveness is achieved through a customer-centric approach. The concept of value is closely linked to efficiency and effectiveness, with exchange and use value being significant manifestations. Assessing organizational performance without considering contextual factors may present challenges when evaluating activity systems rather than organizations [7].

Supply chain management (SCM) is considered a comprehensive process that focuses on the interdependence of buyer and supplier firms in enhancing the entire supply chain. It optimizes the entire network, from suppliers to manufacturers, ultimately leading to the delivery of goods or services to the end client. SCM is a crucial determinant of firm performance, connecting end customers, distribution channels, production processes, and procurement activities. However, research on measuring supply chain performance effectiveness is limited, particularly in developed countries. It is a comprehensive methodology that encompasses the strategic coordination and oversight of various interconnected components, including materials, logistics, services, and information flows [8].

Supply chain efficiency refers to the extent to which a supply chain is able to deliver products and services to the end customer with minimal resources, waste, or redundancies [5]. Various strategies can be employed to enhance efficiency, including lean management, process optimization, technology integration, and improved supplier relationships [9,10].

Lean management, a concept derived from the Toyota Production System, is known for its emphasis on reducing waste to enhance efficiency [11]. According to Fullerton, Kennedy, & Widener implementing lean principles in the supply chain can significantly improve operational efficiency by minimizing waste and optimizing resources [12].

Huang et al. assert that the incorporation of technology is of paramount importance in enhancing the efficiency of supply chain operations [9]. The utilization of advanced technologies, including the Internet of Things (IoT), Artificial Intelligence (AI), and blockchain, presents promising prospects for enterprises to optimize their supply chain operations, augment transparency, enhance traceability, and facilitate data-driven decision-making in real-time [13,14].

Managing supplier relationships is a crucial component of ensuring supply chain efficiency. The study conducted by Flynn et al. emphasizes the importance of incorporating supplier integration as a means to improve overall supply chain efficiency [10]. Through the establishment of robust and mutually beneficial partnerships with suppliers, firms have the opportunity to seamlessly incorporate them into their organizational operations, thereby fostering a streamlined and effective supply chain. By working closely with suppliers and integrating them into their processes, firms can gain valuable insights into their operations and supply chain. This level of collaboration allows for better communication, coordination, and ultimately, more effective decision-making. In turn, this can lead to cost savings, improved product quality, and increased customer satisfaction. Overall, supplier integration plays a key role in optimizing supply chain performance and driving overall business success.

According to Ivandianto & Tarigan, Supply chain management (SCM) is an integral component of business administration that encompasses the coordination and integration of diverse systems and inter-company networks [15]. The system in question effectively oversees the regulation of materials, logistics, services, and the flow of information. This enables the smooth and efficient transfer of resources from suppliers to producers or clients. By integrating various stakeholders, such as suppliers, manufacturers, distributors, and customers, SCM aims to optimize the flow of goods, information, and finances throughout the supply chain network. This integration allows for improved coordination and collaboration among stakeholders, leading to enhanced operational efficiency and effectiveness. One of the key benefits of SCM is its ability to improve customer satisfaction. By streamlining processes and reducing lead times, SCM enables organizations to meet customer demands more effectively. Additionally, the integration of stakeholders facili-

tates better communication and responsiveness The successful execution of strategic initiatives has been found to have a positive impact on the overall performance and financial success of organizations.

The analysis of Mudimba & Ismael indicates that it would be advantageous for Kenyan manufacturing enterprises to implement economic order quantity, store management, and procurement techniques in order to enhance the efficiency of their supply chains [16]. The integration of quality management techniques, namely product design, defect investigation, and inspection, is imperative within production processes. In order to optimize supplier relationship management, it is imperative to implement a range of effective strategies. These strategies encompass various aspects such as appraisal techniques, selection processes, performance methods, and collaboration with local suppliers.

4. Research Methodology

4.1. Theoretical Framework

In the proposed study titled "Blockchain Technology for Supply Chain Efficiency in a Selected Business in Guangdong, China," the theoretical framework can be developed based on the principles of Distributed Systems as elucidated by Aspnes [17].

The blockchain technology is essentially a decentralized system in which multiple nodes engage in executing their own programs. These nodes are influenced by the receipt of messages, the observation of shared-memory updates, and the monitoring of the states of other devices [17]. Within this particular system, it is important to note that there exists a decentralized structure devoid of any central authority. Instead, what prevails is a network comprising autonomous nodes that undertake the crucial task of validating transactions. The fundamental basis for the properties of immutability, transparency, and peer-to-peer consensus, which are the core attributes of blockchain technology, is derived from the structural framework of this system.

The management of distributed systems becomes more intricate as the scale of the system expands, thereby emphasizing the difficulties associated with forecasting or comprehending their behavior. The observed complexity can be attributed to the absence of universally adopted tools for effectively managing extensive distributed systems, as well as the inherent unpredictability inherent in such systems. These unpredictabilities encompass various factors, such as unforeseen delays in message arrivals or abrupt component failures [17].

The decentralized nature and inherent security of blockchain render it a highly promising technology for augmenting supply chain efficiency. Considering the extensive magnitude and intricate nature of supply chains, especially within regions such as Guangdong, China, it is worth exploring the potential integration of blockchain technology as a means to enhance the management of these intricate systems.

Distributed systems are comprised of a collection of interconnected devices, each running their own independent programs. These devices interact with each other through the exchange of messages, updates to shared memory, or by observing the states of other devices within the system. As the scale of these systems expands, the complexity of predicting and comprehending their behavior increases, primarily attributed to their inherent nondeterministic nature and vast magnitude. In order to evaluate or replicate these systems, it is imperative to employ theoretical methodologies that can establish the validity of their properties and enable their utilization with a high level of certainty. Automaton-based models are commonly employed to delineate and conceptualize the intricate dynamics of large-scale distributed systems, effectively capturing and encapsulating pertinent characteristics. These models serve as abstractions, distilling the essential properties that are germane to the system under scrutiny [17].

The present study aims to employ a theoretical framework to direct the inquiry into the potential augmentation of supply chain efficiency through the utilization of blockchain technology within a specific business entity situated in Guangdong, China. The

statement establishes the foundation for assessing the possible advantages and obstacles associated with the implementation of this particular technology within the context of supply chain operations.

Blockchain is essentially a distributed ledger system that requires no central authority. The distributed systems theory, which covers aspects like fault tolerance, concurrency, synchronization, and data replication, is essential in understanding how blockchain operates and maintains consensus across the network [18].

The hypotheses of thus research included:

H1: There is no significant difference in the level of blockchain technology integration across different demographics within the organization.

H2: The integration of blockchain technology in terms of immutability, transparency, and peer-to-peer consensus is significantly related to the level of supply chain efficiency.

H3: There is no significant difference in the perceptions of supply chain efficiency across different demographic groups within the organization.

4.2. Research Design

The selected research design for this study was a comparative-correlational design, which was a part of the quantitative research concept. The chosen design for this study was considered suitable due to its capacity to facilitate the examination of relationships between two or more variables. The future study aimed to examine the correlation between the degree of integration of blockchain technology and the evaluation of supply chain efficiency.

In addition, the incorporation of a comparative aspect in the design was highly significant as it enabled the researcher to analyze variations in integration levels and supply chain efficiency among different groups of respondents, specifically classified according to their demographic characteristics. This comparative analysis facilitated the identification of potential correlations between variations in respondent profiles and disparities in the levels of blockchain integration and perceived supply chain efficiency.

A comparative-correlational design was considered suitable because of its ability to not only determine the presence of a relationship but also to identify differences among different groups, providing a comprehensive perspective of the situation at hand. In addition, a quantitative methodology was used to enable an unbiased evaluation of the variables being studied. Statistical techniques were employed to analyze the data.

The inherent quantitative nature of the chosen research design effectively enabled the measurement and assessment of relationships and disparities, providing valuable insights for the subsequent formulation of a strategic plan. This approach relied on the utilization of concrete numerical evidence to inform decision-making and guide the strategic planning process.

This particular research design was frequently observed in investigations that sought to ascertain and comprehend the connections between variables and disparities among groups, with the ultimate objective of enhancing decision-making and planning procedures within diverse organizational settings [19].

Therefore, the utilization of a comparative-correlational design within a quantitative framework yielded the most precise and all-encompassing outcomes for this specific investigation. It considered the inherent characteristics of the research inquiries and the imperative requirement to acquire a profound comprehension of the intricate interplay between blockchain integration and supply chain efficiency.

4.3. Participants

In this investigation, a random sampling technique was implemented to ascertain the selection of participants. The study involved the inclusion of participants from diverse departments and hierarchical positions within the organization. The primary objective of

employing a random sampling technique was to ascertain a just representation of the population under investigation. This approach ensured that every employee, regardless of their department or position within the organization, was given an equal opportunity to be selected for inclusion in the sample. The implementation of this approach contributed to the improvement of the study's findings in terms of their applicability and relevance to the entire organization. The precise number of participants was determined based on the dimensions of the organization and the rate of response, ensuring a statistically significant analysis.

Currently, there are 4,576 employees in the business. Hence, 355 employees were selected.

4.4. Instrument

The primary instrument for this study was a researcher-made questionnaire. The instrument consisted of questions that related to the level of integration of blockchain technology and the assessment of supply chain efficiency.

Data about the respondents' profile, including their sex, age, and position within the organization, was gathered through Demographic and Professional Information. This information was used to group the respondents for comparative analysis.

The Level of Integration of Blockchain Technology had three sub-sections, each corresponding to the defined sub-constructs: Immutability, Transparency, and Peer-to-Peer Consensus. Each sub-section contained six statements, and respondents rated their level of agreement with each statement on a 4-point Likert scale.

The Assessment of Supply Chain Efficiency had four sub-sections, each representing a sub-construct: Materials, Logistics, Services, and Information Flows. In the previous section, each sub-section contained six statements, and respondents rated their level of agreement with each statement on a 4-point Likert scale.

The validity and reliability of the questionnaire were ensured through a rigorous process. Content validity, which related to the extent to which the instrument covered the construct of interest, was ensured through expert reviews. A panel of experts in the fields of blockchain technology and supply chain management was asked to review the questionnaire for its relevance and comprehensiveness.

A pilot test was conducted on a small sample from the population to assess the reliability of the instrument, which refers to its consistency. The consistency of their responses was measured using Cronbach's Alpha, a commonly used statistical test for internal consistency. An alpha value of 0.7 or higher was generally considered acceptable for research purposes, according to Nunnally [20,21].

4.5. Data Gathering Procedure

The data gathering procedure for the research study started with obtaining formal permission from the relevant organizations after the research proposal was approved. The study's purpose and significance were conveyed to the respective authorities, along with assurances about the confidentiality of the information obtained [22].

After that, the participants for the study were identified by the researcher using a random sampling method to ensure a broad representation for results that could be generalized. An invitation was sent to the chosen employees, providing details about the study and requesting their consent to participate.

After the participants agree, the researchers will distribute the questionnaires. This could be accomplished either in person or through digital platforms, depending on what was most convenient and effective for the respondents [23].

After the respondents finished the questionnaires, the researchers gathered them for data analysis. For digital distribution, a deadline was established for respondents. Following this, the researchers collected the responses for further evaluation.

Before commencing data analysis, the researchers thoroughly verified the responses to identify any inconsistencies or missing data. If there were any discrepancies, respondents would have been contacted for clarification or rectification. Such a systematic approach to data collection ensured that the study maintained high ethical standards and resulted in reliable and valid data.

4.6. Statistical Result of the Data

The data went through careful examination through rigorous statistical analysis. Preceding the analysis phase, the data will undergo processing and encoding procedures to ensure compatibility with an appropriate software program. The selection of an appropriate software program is contingent upon the level of complexity inherent in the statistical analyses to be conducted. Ideally, a software package possessing a comprehensive suite of statistical techniques would be preferred, with notable examples including SPSS or R.

4.6.1. Data Result of Blockchain Technology

Table 1 presents a comparative analysis of the level of blockchain technology integration with respect to the sex of the respondents. The table includes t-tests, which are statistical examinations of two population means. A series of t-tests have been conducted to ascertain whether there are significant differences between male and female respondents in their perceptions of the integration of blockchain technology in terms of immutability, transparency, and peer-to-peer consensus.

Table 1. Differences in the level of integration of blockchain technology in terms of sex.

Indicator	Sex	Mean	t	Sig.	Decision on Ho	Interpretation
Immutability	Male	2.953	0.998	0.318	Accepted	Not Significant
	Female	3.024				
Transparency	Male	2.986	5.229	0.023	Rejected	Significant
	Female	2.945				
Peer-to-peer consensus	Male	2.993	1.396	0.238	Accepted	Not Significant
	Female	2.909				
Overall	Male	2.233	3.725	0.054	Rejected	Significant
	Female	2.219				

For the construct of immutability, the t-test results in a significance (Sig.) value of 0.318, which is greater than the conventional alpha level of 0.05, leading to the acceptance of the null hypothesis (Ho). This indicates that there is no statistically significant difference between the male and female respondents' views on the integration of blockchain in terms of immutability.

Regarding transparency, the Sig. value is 0.023, which is less than 0.05, resulting in the rejection of the null hypothesis. This suggests that there is a statistically significant difference between the sexes, with male respondents having a slightly higher mean (2.986) compared to female respondents (2.945). This difference signifies that males and females perceive the transparency provided by blockchain in different ways, or to different extents.

For peer-to-peer consensus, the Sig. value of .238 leads to the acceptance of the null hypothesis, implying no significant difference between male and female respondents in this aspect.

The overall test for differences in the level of blockchain integration across sex yields a Sig. value of 0.054, which is marginally above the 0.05 threshold but results in the rejection of the null hypothesis. This points to a borderline significant difference between males and females in their overall perception of blockchain integration, suggesting that while differences exist, they are not pronounced.

In summary, the data indicates that for certain aspects of blockchain technology integration, namely transparency and overall integration, there are significant differences between male and female respondents. However, for immutability and peer-to-peer consensus, the sexes appear to share similar perceptions. These findings could have implications for the targeted adoption and implementation strategies of blockchain technology within the organization, potentially requiring gender-specific considerations.

Table 2 provides an analysis of the differences in the level of blockchain technology integration among various age groups. The analysis uses an F-test to determine if there are significant differences in means between the groups.

Table 2. Differences in the level of integration of blockchain technology in terms of age.

Indicator	Age	Mean	F	Sig.	Decision on Ho	Interpretation
Immutability	25-35	3.078	1.421	0.236	Accepted	Not Significant
	36-45	2.966				
	46-55	2.906				
	56-above	2.967				
Transparency	25-35	2.916	1.779	0.151	Accepted	Not Significant
	36-45	2.947				
	46-55	3.093				
	56-above	2.950				
Peer-to-peer consensus	25-35	2.956	1.391	0.245	Accepted	Not Significant
	36-45	2.922				
	46-55	3.067				
	56-above	2.869				
Overall	25-35	2.238	0.794	0.498	Accepted	Not Significant
	36-45	2.209				
	46-55	2.266				
	56-above	2.197				

For the construct of immutability, the F-test result indicates no significant difference among the different age groups, with a Sig. value of 0.236. This suggests that across the age spectrum from 25 to over 55, there is a general consensus on the role of blockchain technology in ensuring the immutability of records.

In terms of transparency, the Sig. value is 0.151, which also leads to the acceptance of the null hypothesis, indicating that there are no statistically significant differences between the age groups. This reflects a shared perception of the transparency aspect of blockchain technology across different ages.

Regarding peer-to-peer consensus, the Sig. value of 0.245 further supports the acceptance of the null hypothesis across age groups. This implies that the respondents, regardless of age, similarly perceive the integration of blockchain technology in achieving decentralized consensus within the organization.

The overall analysis across all constructs shows a Sig. value of 0.498, well above the commonly used significance level of 0.05. Consequently, the null hypothesis is accepted, indicating no significant differences in the overall perception of blockchain technology integration among the different age groups.

The findings suggest that the perception of blockchain technology's integration into supply chain processes is uniformly distributed across the age groups within the organization. This could imply that the understanding and acceptance of blockchain technology are not limited by the age of the employees, which is beneficial for organizations looking to implement such technology across a diverse workforce. It may also indicate that educational and training efforts regarding blockchain have been effective across the organization's demographic.

Table 3 provides an analysis of the differences in the level of integration of blockchain technology across various organizational positions, using a one-way ANOVA test to determine if the mean scores for each position category significantly differ.

Table 3. Differences in the level of integration of blockchain technology in terms of position.

Indicator	Position	Mean	F	Sig.	Decision on Ho	Interpretation
Immutability	Executive Middle Management Supervisory Specialist Support Staff	3.171 2.956 3.028 2.846 2.950	3.024	0.018	Rejected	Significant
Transparency	Executive Middle Management Supervisory Specialist Support Staff	3.089 2.990 2.882 2.913 2.924	2.013	0.092	Accepted	Not Significant
Peer-to-peer consensus	Executive Middle Management Supervisory Specialist Support Staff	3.007 3.078 2.960 2.731 2.894	3.780	0.005	Rejected	Significant
Overall	Executive Middle Management Supervisory Specialist Support Staff	2.317 2.256 2.217 2.122 2.192	4.150	0.003	Rejected	Significant

For the construct of immutability, the analysis shows a significant difference among the various positions (Sig. 0.018), indicating that the perceptions of blockchain's role in ensuring unalterable records vary significantly depending on the respondent's role within the organization. Executives reported the highest mean score (3.171), suggesting they perceive a greater integration of blockchain for ensuring immutability in their operations compared to other positions.

In the case of transparency, the differences among positions are not statistically significant (Sig. 0.092), implying that employees across different levels of the organization have a relatively uniform perception of the transparency afforded by blockchain technology.

For peer-to-peer consensus, there is a significant difference among the different organizational positions (Sig. 0.005), with middle management having the highest mean score (3.078). This suggests that those in middle management perceive a greater integration of blockchain technology for enabling decentralized decision-making compared to their counterparts in other roles.

Lastly, the overall test for differences in the level of blockchain integration across positions is also significant (Sig. 0.003), highlighting that there is a significant variation in the overall perception of blockchain integration among different positions within the organization.

In conclusion, the findings from Table 3 suggest that while the integration of blockchain technology is acknowledged across the organization, there are significant differences in perceptions based on the respondents' job roles. This could indicate varying levels of exposure to or understanding of blockchain technology among different organizational tiers. Such insights could be vital for developing role-specific blockchain integration strategies and training programs.

4.6.2. Data Result of Supply Chain Efficiency

Table 4 explores the differences in the assessment of supply chain efficiency in terms of sex, using the t-test for equality of means across male and female respondents.

Table 4. Differences in the assessment of supply chain efficiency in terms of sex.

Indicator	Sex	Mean	t	Sig.	Decision on Ho	Interpretation
Materials	Male	2.923	0.494	0.482	Accepted	Not Significant
	Female	2.849				
Logistics	Male	2.921	2.401	0.122	Accepted	Not Significant
	Female	3.014				
Services	Male	2.728	2.514	0.114	Accepted	Not Significant
	Female	2.786				
information flows	Male	2.813	4.030	0.045	Rejected	Significant
	Female	2.853				
Overall	Male	2.858	1.094	0.296	Accepted	Not Significant
	Female	2.883				

In the assessment of materials, the means for males and females are 2.923 and 2.849, respectively, with a significance level of 0.482, which is higher than the conventional alpha level of 0.05. This results in the acceptance of the null hypothesis, indicating that there is no statistically significant difference between males and females in their assessment of supply chain efficiency as it pertains to materials.

Looking at logistics, while there is a slight difference in the means — 2.921 for males and 3.014 for females — the significance level of 0.122 also leads to the acceptance of the null hypothesis, suggesting that the perceived efficiency of logistics operations due to blockchain technology is not significantly different between the sexes.

For services, the means are relatively close (2.728 for males and 2.786 for females), and with a significance level of 0.114, the null hypothesis is again accepted, indicating no significant difference in perceptions of service efficiency between male and female respondents.

Interestingly, when assessing information flows, the significance level is 0.045, which is just below the 0.05 threshold, leading to the rejection of the null hypothesis. This implies a statistically significant difference between the sexes, with females (mean of 2.853) slightly more likely than males (mean of 2.813) to perceive blockchain technology as having a positive impact on the efficiency of information flows.

Overall, when considering all categories combined, the significance level is 0.296, and the null hypothesis is accepted. This suggests that there are no significant differences between males and females in the overall assessment of supply chain efficiency due to blockchain technology.

In summary, the data from Table 4 indicates that gender does not play a significant role in the assessment of supply chain efficiency in most categories, with the exception of information flows, where a significant difference exists. This could point to potential gender-related differences in perception or experience with blockchain technology's impact on information flow within supply chains.

Table 5 presents a statistical analysis of the differences in the assessment of supply chain efficiency across various age groups within an organization. The ANOVA test is utilized to determine if there are statistically significant differences in the mean scores for each age category.

Table 5. Differences in the assessment of supply chain efficiency in terms of age.

Indicator	Age	Mean	F	Sig.	Decision on Ho	Interpretation
Materials	25-35	2.977	2.368	0.071	Accepted	Not Significant
	36-45	2.876				
	46-55	2.774				
	56-above	2.814				
Logistics	25-35	2.970	2.368	0.071	Accepted	Not Significant
	36-45	3.026				
	46-55	3.043				
	56-above	2.852				
Services	25-35	2.778	1.445	0.229	Accepted	Not Significant
	36-45	2.739				
	46-55	2.871				
	56-above	2.679				
information flows	25-35	2.803	2.990	0.031	Rejected	Significant
	36-45	2.737				
	46-55	2.947				
	56-above	2.929				
Overall	25-35	2.908	2.315	0.076	Accepted	Not Significant
	36-45	2.880				
	46-55	2.896				
	56-above	2.782				

For materials, the F-value is 2.368 with a significance level of 0.071, which is above the commonly used threshold of 0.05. As a result, the null hypothesis is accepted, indicating no significant differences among the age groups in their assessment of the efficiency of materials in the supply chain.

In terms of logistics, the age groups again do not show significant differences, with the same F-value of 2.368 and a significance level of 0.071. This suggests that the perceived efficiency of logistics due to blockchain technology is uniformly assessed across different age groups.

When assessing services, the F-value is lower at 1.445 with a significance level of 0.229, leading to the acceptance of the null hypothesis. This indicates a consensus across the age categories in terms of how blockchain technology impacts service efficiency within the supply chain.

However, the assessment of information flows shows a different pattern. With an F-value of 2.990 and a significance level of 0.031, the null hypothesis is rejected for this indicator. This suggests significant differences in the perception of information flow efficiency due to blockchain technology among the different age groups. The means suggest that the 46-55 and 55-above age groups perceive a more pronounced impact of blockchain on information flow efficiency compared to the 25-35 and 36-45 groups.

The overall assessment across all categories of supply chain efficiency has an F-value of 2.315 and a significance level of 0.076, which results in the acceptance of the null hypothesis, indicating no overall significant differences among the age groups in their assessment of supply chain efficiency due to blockchain technology.

In summary, while the assessment of supply chain efficiency due to blockchain technology in terms of materials, logistics, and services does not differ significantly across age

groups, there are significant differences in how these groups perceive the impact of blockchain on information flows. This finding may highlight the need for further exploration into how different age demographics interact with and perceive the benefits of blockchain technology in the context of information management within supply chains.

Table 6 offers a detailed examination of the differences in the assessment of supply chain efficiency across various positions within an organization. The table utilizes an ANOVA test to discern if there are statistically significant differences between the mean scores of executives, middle management, supervisory, specialists, and support staff.

Table 6. Differences in the assessment of supply chain efficiency in terms of position.

Indicator	Position	Mean	F	Sig.	Decision on Ho	Interpretation
Materials	Executive	2.751	4.095	0.003	Rejected	Significant
	Middle Management	2.831				
	Supervisory	2.845				
	Specialist	2.884				
	Support Staff	3.095				
Logistics	Executive	2.975	1.203	0.309	Accepted	Not Significant
	Middle Management	2.994				
	Supervisory	3.042				
	Specialist	2.903				
	Support Staff	2.936				
Services	Executive	2.768	1.211	0.306	Accepted	Not Significant
	Middle Management	2.770				
	Supervisory	2.638				
	Specialist	2.822				
	Support Staff	2.806				
Information flows	Executive	2.845	1.665	0.158	Accepted	Not Significant
	Middle Management	2.803				
	Supervisory	2.744				
	Specialist	2.975				
	Support Staff	2.825				
Overall	Executive	2.831	1.153	0.332	Accepted	Not Significant
	Middle Management	2.865				
	Supervisory	2.841				
	Specialist	2.870				
	Support Staff	2.946				

For the assessment of materials, the ANOVA results indicate a significant difference among the different positions within the organization (Sig. 0.003). The null hypothesis is rejected, and this finding is considered significant. Notably, support staff have the highest mean score (3.095), indicating they perceive a greater efficiency in material management due to blockchain technology compared to other positions.

In contrast, the logistics assessment shows no significant difference among the different positions, with a Sig. value of 0.309. This suggests a general consensus across organizational roles regarding the efficiency of logistics operations due to blockchain integration.

Similarly, the services assessment does not display significant differences across positions, with a Sig. value of 0.306. This implies uniformity in how the efficiency of services due to blockchain technology is perceived, regardless of the respondent's role.

The assessment of information flows also shows no significant difference among the positions within the organization, as indicated by a Sig. value of 0.158. While there may be slight variances in the means, these differences are not enough to suggest a statistically significant discrepancy in perceptions based on organizational role.

Overall, when all categories are combined, the Sig. value of 0.332 suggests there is no significant difference in the overall assessment of supply chain efficiency due to blockchain technology across different job roles. This indicates a broadly consistent perception of blockchain's impact on supply chain efficiency among all employees, regardless of their position.

In summary, the data from Table 6 suggests that perceptions of blockchain technology's impact on supply chain efficiency in terms of materials are significantly different depending on the respondent's job role, with support staff reporting higher efficiency. For the other aspects — logistics, services, and information flows — there is no significant difference in perception across various positions, pointing to a general agreement on blockchain's role in these areas.

4.6.3. Data Result of Blockchain Technology and Supply Chain Efficiency

Affiliation(s) should be justified, including organisation, address and e-mail.

Table 7 presents the correlation analysis between the level of integration of blockchain technology in terms of immutability and the assessment of supply chain efficiency across various domains: materials, logistics, services, and information flows. The correlation coefficient (r) values are quite low and the significance (Sig.) values are high across all categories, leading to the acceptance of the null hypothesis in each case.

Table 7. Correlation between the level of integration of blockchain technology and the assessment of supply chain efficiency.

Blockchain Technology	Supply Chain Efficiency	r	Sig.	Decision on Ho	Interpretation
Immutability	Materials	-0.007	0.894	Accepted	Not Significant
	Logistics	-0.001	0.987	Accepted	Not Significant
	Services	-0.091	0.085	Accepted	Not Significant
	Information flows	-0.068	0.202	Accepted	Not Significant
Transparency	Materials	0.055	0.302	Accepted	Not Significant
	Logistics	0.064	0.225	Accepted	Not Significant
	Services	0.032	0.545	Accepted	Not Significant
	Information flows	0.062	0.241	Accepted	Not Significant
Peer-to-peer consensus	Materials	-0.026	0.625	Accepted	Not Significant
	Logistics	0.244**	0.000	Rejected	Significant
	Services	0.052	0.332	Accepted	Not Significant
	Information flows	0.033	0.535	Accepted	Not Significant

Average Blockchain Technology	Average Supply Chain Efficiency	0.056	0.291	Accepted	Not Significant

For materials and logistics, the correlation is almost non-existent, with r values of -0.007 and -0.001, respectively, and high Sig. values (0.894 and 0.987). This suggests that there is no significant relationship between the perceived immutability aspect of blockchain technology and the efficiency of materials handling or logistics operations. Similarly, services and information flows show very weak, inverse correlations with immutability (r values of -0.091 and -0.068, respectively) and are not statistically significant (Sig. values of 0.085 and 0.202). These results indicate that within this dataset, there is no evidence to support a significant association between the level of blockchain integration in terms of ensuring immutability and the efficiency of supply chain operations in these areas.

The correlation analysis concerning the integration of blockchain technology in terms of transparency and its impact on supply chain efficiency across different areas — materials, logistics, services, and information flows — shows no significant relationship. The correlation coefficients are very low (ranging from 0.032 to 0.064), and the significance levels are all above the conventional 0.05 threshold, resulting in the acceptance of the null hypothesis for all areas. These findings suggest that, within the scope of this study, there is no substantial evidence to conclude that the level of transparency provided by blockchain technology has a significant impact on the efficiency of the supply chain, whether it be in terms of materials management, logistics operations, service delivery, or the flow of information. While blockchain's transparency is valuable, it may not directly lead to measurable efficiency improvements. Organizations should consider other factors and technologies to drive efficiency, such as integrating blockchain transparency with other operational improvements and investing in training and change management. The current maturity level of blockchain technology may also impact efficiency. Therefore, businesses need to align blockchain with complementary technologies and strategic frameworks.

The correlation analysis for the role of peer-to-peer consensus through blockchain technology in enhancing supply chain efficiency presents a mixed picture. While most areas — materials, services, and information flows — do not show a significant correlation, logistics stands out with a significant positive correlation (r = 0.244, Sig. = 0.000). This suggests that within the logistics aspect of the supply chain, the decentralized decision-making enabled by blockchain's peer-to-peer consensus is perceived to contribute significantly to efficiency. The non-significant correlations in materials, services, and information flows indicate that the benefits of peer-to-peer consensus may not be universally recognized across all supply chain functions or may not manifest in a directly measurable way. This could imply that the impact of blockchain technology on supply chain efficiency is more nuanced and may depend on specific operational contexts or the manner in which the technology is implemented. The significant result in logistics implies that this area of the supply chain might be particularly amenable to the advantages offered by blockchain, such as improved coordination and reduced bottlenecks, which can lead to clearer communication channels and faster turnaround times. This significant finding could encourage businesses to delve deeper into the application of blockchain in logistics to further understand and capitalize on these efficiencies. Thus, the findings underscore the importance of a targeted approach when integrating blockchain technology into supply chain operations. They suggest that blockchain's peer-to-peer consensus mechanism has the potential to enhance certain aspects of the supply chain, particularly logistics, and that further exploration and strategic implementation may be warranted in areas where a significant impact has been identified.

The correlation result showing an R-value of 0.056 with a significance level of 0.291 indicates that there is a very weak, non-significant positive correlation between the average level of blockchain technology integration and the average supply chain efficiency. The acceptance of the null hypothesis suggests that, based on the data analyzed, there is

no substantial evidence to support the claim that blockchain technology integration has a significant impact on supply chain efficiency. This finding implies that while blockchain technology is being integrated into supply chain operations, it is not yet a key driver of efficiency, or at least not in a detectable manner with the current level of implementation. It could also indicate that blockchain's contributions to supply chain efficiency are more complex and might be influenced by other variables not captured in this analysis. The practical implication for businesses is that merely adopting blockchain technology does not automatically result in improved supply chain efficiency. Companies may need to consider other factors, such as the specific use case of blockchain, the technology's integration with existing systems, employee training, and the overall digital transformation strategy of the organization. This result could also reflect the early stages of blockchain adoption in supply chains, where its full potential to streamline operations and enhance efficiency has yet to be fully realized and measured.

5. Conclusions

The study's findings are notably influenced by the gender distribution, with a higher representation of females (56.6%) compared to males (43.1%). Moreover, respondents predominantly fall within the 25-45 age ranges, indicating a demographic characterized by dynamism and openness to technological advancements such as blockchain. However, the lower representation of older age groups suggests a potential bias towards less experienced perspectives. Furthermore, the distribution across hierarchical levels within organizations, with middle management being most represented, suggests that the study's insights may primarily reflect the views of management and supervisory roles, thereby potentially influencing the adoption and perceived efficiency of blockchain in supply chains.

The study underscores the significant role of blockchain technology within organizational operational frameworks, particularly in terms of record immutability. Respondents express high confidence in the concept of unalterable records, with transparency through blockchain being integrated into operations to a considerable extent. Notably, the decentralized aspect of blockchain technology is valued, as indicated by the belief that peer-to-peer consensus reduces reliance on central authority.

Blockchain integration demonstrates moderate levels of efficiency in materials management, with significant reductions in waste observed. However, there is some skepticism regarding its significant contribution to material management. Similarly, while improvements are noted in inventory management and logistics operations, challenges such as errors and delays persist, suggesting opportunities for further enhancement to reach higher efficiency levels.

The study finds no significant differences in perceptions of blockchain integration between male and female respondents. However, variations are observed among different hierarchical positions within organizations, with executives reporting the highest mean score for immutability. Despite this variation, there is a general consensus across organizational roles regarding the efficiency of logistics operations due to blockchain integration.

Overall, the study reveals a broadly consistent perception of blockchain's impact on supply chain efficiency among all employees, irrespective of job roles. No significant differences are found in the assessment of supply chain efficiency across different demographics, indicating a unified understanding of blockchain's role in enhancing operational effectiveness.

The study presents a mixed picture regarding the relationship between blockchain integration and supply chain efficiency. While peer-to-peer consensus through blockchain technology exhibits a significant positive correlation with logistics efficiency, other areas lack conclusive evidence of impact. Moreover, the study finds no substantial evidence to support the claim that blockchain technology integration significantly impacts overall

supply chain efficiency, highlighting the need for further research and exploration in this domain.

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