Enhancing Supply Chain Efficiency and Transparency: A Conceptual Model for Blockchain Adoption and Human Capital Development within the TOE Framework

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Abstract
This study intends to develop a model that comprehensively presents how the different effects of vital variables all contribute to the efficiency and transparency of the supply chains which will be grounded within the theory of Technology-Organization-Environment. The methodology proposed follows Saunders' Research Onion and presents a positivist research philosophy by which quantitative data is valued. The research will also be deductive; it will begin by testing theory on blockchain and supply chain management to examine them through the proposed model. The research strategy involves quantitative survey designed for supply chain professionals across all other industries, be it transportation & logistics, and food & beverage. This study develops a conceptual model, which in fact was exhaustive, that showed how the different influences of key variables really affected supply chain efficiency and transparency. This model was built using Technology-Organization-Environment for the said study. Amongst such factors include: blockchain technology adoption, awareness and education of stakeholders, regulatory frameworks, and development of human capital while investigating the moderating effect of organizational readiness regarding these relationships. Data would be collected through structured online surveys testing the five proposed hypotheses regarding the effect of blockchain adoption on supply chain performance. According to the literature, a skilled workforce and stakeholder education are essential in maximizing the potential benefits of blockchain technology. The study further reinforces the requirement of supportive regulatory frameworks, which facilitate the adoption and integration of the technology. Therefore, practitioners, policymakers, and researchers can draw from this work for valuable insights into utilizing blockchain technology strategically to improve supply chain processes. Suggestions for future research directions included the need for empirical testing of the proposed model, longitudinal studies that track change over time, and consideration of other influencing variables across various industries and regions.

Keywords: supply chain, efficiency, transparency, blockchain technology, human capital,

TOE framework, adoption, organizational readiness, stakeholder education, regulatory frameworks

Background of the study
Particularly in developing nations like Pakistan, blockchain technology is becoming more widely acknowledged as a revolutionary force in supply chain management. Blockchain integration into supply chains has a lot of promise to improve security, efficiency, and transparency—all of which are vital for tackling the issues facing the Pakistani economy. With a variety of industries, such as manufacturing, textiles, and agriculture, Pakistan stands to gain a great deal from the adoption of blockchain-technology.

The application of blockchain technology to supply chains has become more popular worldwide, with businesses from a variety of industries using it to enhance operations. Blockchain technology has been used by big businesses like IBM and Walmart to track food products from farm to table, guaranteeing their quality and safety. This has established a standard for industries in developing countries, emphasizing the possible advantages of traceability and transparency (Kouhizadeh & Sarkis,2024).

Blockchain is being used more and more by international brands in the textile sector to prevent counterfeiting and guarantee ethical sourcing. Consumer trust and brand reputation are improved when products can be authenticated using blockchain records. In Pakistan, the textile sector can use blockchain technology to enhance adherence to ethical and labor standards, reflecting this trend (Agi & Jha, 2024).

For supply chains to successfully adopt blockchain technology, human capital development is essential. To effectively manage and use blockchain systems, the workforce needs to be prepared with the requisite abilities and expertise. This covers instruction in blockchain protocols, data management, and cyber security. The need for qualified experts who can close the gap between conventional supply chain procedures and cutting-edge blockchain solutions will rise sharply as Pakistani businesses start implementing these technologies (Du, 2024).

Globally, nations like Germany and the Netherlands have effectively incorporated blockchain technology into their supply chains, showcasing notable gains in transparency and efficiency. To prepare the workforce for new technologies, these examples emphasize the value of stakeholder collaboration as well as the necessity of ongoing education and training (Kouhizadeh & Sarkis, 2024). Human capital development is crucial in this situation, and companies need to fund training initiatives that give staff members the know-how to handle the digital transformation. This encompasses both technical and soft skills, such as flexibility and problem-solving, which are critical in a rapidly evolving technological environment.

Effective data management and analysis skills are becoming more and more important as globalization continues to influence supply chains. Blockchain allows for real-time information access throughout the supply chain in addition to offering a safe means of data storage. Organizations can react to market shifts and customer demands faster thanks to this capability, which improves decision-making processes (Du, 2024).

Although there are many obstacles to overcome before blockchain can be widely used in Pakistani supply chain management, there are also a lot of potential advantages. Pakistan can use blockchain technology to improve its supply chain efficiency and competitiveness in the global market by tackling these issues through cooperation, education, and supportive policies. To fully benefit from blockchain, human capital must

be strengthened through focused education and training. The future of supply chain management in Pakistan can be greatly enhanced, opening the door for long-term economic growth, provided stakeholders collaborate to remove obstacles and welcome innovation.

Problem Statement

Blockchain in Pakistan faces a number of challenges despite its potential. Growth is slowed by technical barriers like inadequate internet access and infrastructure. Adoption may also be hampered by stakeholders' ignorance of blockchain technology. Wider deployment may be hampered by regulatory uniformity and uncertainty. Stakeholder participation is necessary for blockchain solutions, but it can be challenging in a supply chain that is fragmented (Agi & Jha, 2024).

Supply chain management using blockchain technology has the potential to revolutionize operations, particularly in developing countries like Pakistan.

Nevertheless, the government faces significant challenges in implementing this innovative technology. Despite blockchain's potential to increase transparency, efficiency, and security, Pakistan's supply chain ecosystem faces challenges that restrict growth. These problems include a lack of internet connectivity, stakeholder awareness, regulatory uncertainty, human capital development, and technological infrastructure.

First, Pakistan lacks a strong technological infrastructure, particularly in rural areas where agriculture is the main economic activity. Stable internet connectivity, which is necessary for blockchain solutions, is lacking in many locations. Supply chain participants' ability to use blockchain networks and exchange real-time data is hampered by their lack of connectivity. Without a strong technological foundation, blockchain benefits cannot be realized.

Second, blockchain technology is unknown to suppliers, government representatives, and business owners. Blockchain and its advantages for supply chain management are unknown to many individuals and businesses. Stakeholders may be reluctant to invest in new technology they don't understand as a result of this knowledge gap. This issue is made worse by a lack of blockchain education programs, as there aren't many qualified professionals who can deploy.Uncertainty in regulations further impedes the adoption of blockchain in Pakistan. Investment is hampered by unclear legal frameworks for emerging technologies. Businesses might be reluctant to take legal risks in the absence of blockchain application norms and standards. In industries like agriculture and textiles, where access to markets depends on both domestic and international standards, this uncertainty is particularly important.

Developing human capital is also essential to the use of blockchain technology.

To handle and utilize blockchain technologies, Pakistani employees require specialized training. Included are cyber security, data management, and soft skills like adaptability and problem-solving. Without skilled employees, businesses cannot optimize the transparency and efficiency of blockchain's supply chain.

Gap Analysis

There are many chances to improve operational effectiveness, security, and transparency in Pakistan's supply chain management by incorporating blockchain technology. A gap analysis, however, identifies important areas where existing capabilities do not meet the standards required for successful implementation. The gaps in technology, awareness, regulatory frameworks, and human capital development are identified in this analysis.

1. Current-State-Technological-Infrastructure

Pakistan's technological infrastructure is lacking, especially in rural areas where a lot of supply chain activity takes place. Implementing blockchain solutions, which need strong digital networks for real-time data sharing and stakeholder communication, is hampered by limited internet access and erratic connectivity.

The gap

The smooth integration of blockchain technology is not supported by the current infrastructure. To close this gap and guarantee that all stakeholders can access and effectively use blockchain systems, large investments in digital infrastructure are required, especially in rural areas.

2. Present-State Stakeholder Education and Awareness

Key stakeholders, such as suppliers, government representatives, and business owners, are generally unaware of blockchain technology. The workings of blockchain technology and its possible benefits for supply chain management are unknown to many people and organizations.

The gap

Adoption of new technologies is hampered by the knowledge gap because stakeholders may be reluctant to make investments in systems they do not fully comprehend. Blockchain-focused educational initiatives are crucial for raising stakeholder awareness and comprehension, which will speed up adoption procedures.

3. Current-State Regulatory Framework

The adoption of blockchain technology in Pakistan is significantly hampered by regulatory uncertainties. Emerging technologies are frequently subject to an ambiguous legal framework, which deters investment.

The gap

Organizations might be hesitant to participate in projects that could put them in danger of legal repercussions if there are unclear rules and guidelines for blockchain applications. The creation of a thorough regulatory framework that takes blockchain technology into account is essential to creating an atmosphere that is conducive to its uptake.

4. Development of Human Capital

The skills required to effectively manage and use blockchain systems are not present in Pakistan's workforce. Professionals with the necessary training to help supply chains adopt blockchain technology are in short supply.

The gap

To build soft skills like problem-solving and flexibility, as well as technical skills like data management and cyber security, targeted training programs are necessary. To guarantee that the workforce is prepared to take advantage of blockchain's full potential, investments in human capital development are crucial.

Objectives of the study

This study's main objectives regarding the application of blockchain technology to supply chain management in Pakistan are

1. To investigate the main obstacles—technological, legal, and awareness-related—that Pakistan's supply chain management faces in implementing blockchain technology.
2. To investigate the possible uses of blockchain technology in Pakistan's supply chain environment, with an emphasis on manufacturing, textiles, and agriculture.
3. To evaluate the effects of blockchain integration on stakeholder trust and

accountability, as well as how it can improve supply chain operations' operational efficiency and transparency.
4. To assess Pakistan's present level of blockchain-related human capital development, identifying skill gaps and training requirements for efficient management and deployment.
5. To formulate practical policy suggestions that tackle legal and compliance issues while fostering a regulatory climate that encourages the use of blockchain in supply chain management.
6.   To create a thorough framework that describes methods and best practices for incorporating blockchain technology into supply chains in a way that works for Pakistan's unique situation.

Significance of the Study
This study is important because it has the potential to shed light on how blockchain technology can improve supply chain management in Pakistan, especially in developing nations. In order to address a number of important areas, this research intends to contribute to both academic literature and real-world applications by examining the opportunities and challenges of the present.

Increasing the Effectiveness of Operations
This study will show how blockchain can improve traceability, cut down on redundancies, and streamline supply chain operations. Through the identification of successful case studies and best practices, the research can offer organizations looking to cut expenses and improve operational efficiency practical insights.

Fostering Openness and Confidence
The ability of blockchain technology to provide an unchangeable record of transactions is one of its major benefits. This study will demonstrate how greater transparency can foster trust between all parties involved, including consumers and producers. For sectors like agriculture and textiles, where trust is vital, an understanding of these dynamics is necessary.

Educating-Policymakers
The study will clarify the legal issues impeding Pakistan's adoption of blockchain technology. The study's identification of legal framework gaps can help policymakers make the necessary adjustments to create an environment that is favorable to blockchain integration. Better governance and compliance standards throughout supply chains may result from this in the end.

Encouragement of Human Capital Development
The results will highlight how crucial it is to build a workforce with the necessary skills to deploy and oversee blockchain systems. The study can support initiatives to improve human capital and match workforce competencies with new technological demands by promoting focused training and educational initiatives.

Promoting Economic Development
Blockchain technology has the potential to boost Pakistan's economy by increasing supply chain transparency and efficiency. The purpose of this study is to demonstrate how improved supply chain management, especially in important industries like textiles

and agriculture, can result in improved market access, more export opportunities, and general economic growth.

Adding to the Body of Knowledge Worldwide
This study will contribute to the body of knowledge already available on supply chain management applications of blockchain, especially in developing nations. By concentrating on Pakistan, the study can offer insightful information and lessons that might be useful in other comparable situations, promoting a more comprehensive comprehension of the potential effects of blockchain.

Literature Review
In today's dynamic market, supply chain efficiency and transparency are essential for enhancing organizational performance and competitiveness. This review of the literature looks at how supply chain efficiency and transparency (a dependent variable) relate to a number of independent variables, including the adoption of blockchain technology, stakeholder education and awareness, the regulatory environment, and the development of human capital. The moderating influence of organizational readiness is also covered.

Adoption of Blockchain Technology
Supply chain management has seen a revolution thanks to blockchain technology, which improves efficiency, traceability, and transparency. Because it is decentralized, stakeholders can share data in real time, which greatly reduces fraud and information asymmetry (Wang et al., 2019).
H1: Supply chain transparency and efficiency are enhanced by the use of blockchain technology.
According to recent studies, companies that use blockchain technology increase operational efficiency by cutting transaction costs and simplifying procedures (Madhani, 2021). For example, blockchain reduces the errors and delays that come with manual processes by enabling smart contracts to execute automatically (Javaid et al., 2021). Additionally, blockchain builds trust between supply chain participants, encouraging cooperation and lowering conflict (Treiblmaier, 2018). According to Queiroz et al. (2020), the implementation of blockchain technology enhances supply chain performance by improving tracking and regulatory compliance.
Visibility can be further improved by integrating blockchain technology with Internet of Things (IoT) devices. According to Kamble et al. (2021), maintaining quality and compliance requires real-time product monitoring. Furthermore, the technology's capacity to support circular economy principles implies that it plays a crucial part in advancing supply chain sustainability (Choudhary et al., 2022).

Awareness and Education of Stakeholders
For supply chain innovations to be implemented successfully, stakeholder education and awareness are essential. Acceptance and use of technologies, like blockchain, are increased when stakeholders are informed about their features and advantages (Patil et al., 2023).
H2: Supply chain efficiency and transparency are positively impacted by increased stakeholder awareness and education.
Stakeholder education has been shown to improve operational outcomes and facilitate technology transitions for organizations (AlShamsi et al., 2022). Stakeholders are more

inclined to adopt practices that improve transparency when they are aware of how blockchain affects accountability and traceability (Vu et al., 2023). Initiatives to raise awareness can lessen resistance to change, making it easier to adopt creative methods that increase productivity (Happy et al., 2023). According to Lee et al. (2021), improved performance metrics are the result of increased engagement in sustainable practices, which is correlated with improved stakeholder education.

Technology literacy training programs are also crucial. According to Dunk et al. (2023), companies that prioritize educational initiatives see increases in employee creativity and productivity. A knowledgeable stakeholder community can be fostered by addressing ethical issues with data security and privacy through comprehensive educational frameworks (Mohammed et al., 2023).

The Regulatory Structure

The regulatory landscape has a big influence on supply chains' adoption of new technologies. By offering rules that guarantee security and compliance, a supportive regulatory framework incentivizes businesses to invest in blockchain technology (Xie et al., 2023).

H3: Supply chain transparency and efficiency are positively impacted by a strong regulatory framework.

According to studies, stakeholder confidence in blockchain applications is increased by explicit regulations pertaining to data sharing, privacy, and security (Mohammed et al., 2023). Organizations may choose to implement blockchain solutions that offer verifiable transaction records in response to regulations requiring transparency in supply chain operations (Park & Li, 2021). On the other hand, technology adoption may be impeded by unclear regulations, which could result in inefficiencies (Kafeel et al., 2023). According to Tchokogué et al. (2022), regulatory incentives have the potential to stimulate blockchain application research and development.

Global supply chains also heavily rely on international regulations. Harmonizing regulations across borders, according to Zhai et al. (2022), promotes interoperability and makes blockchain integration go more smoothly. This is especially important in sectors where compliance is crucial, like food safety and pharmaceuticals (Bai et al., 2023). All parties involved stand to gain from strong regulatory frameworks that boost market competitiveness and consumer trust (Yin et al., 2023).

Development of Human Capital

For supply chains to fully benefit from technology breakthroughs, human capital development is crucial. Employee competencies and skills have a direct impact on how well blockchain and other technologies are implemented and used.

H4: Improved human capital development has a positive impact on supply chain transparency and efficiency.

Organizations that prioritize training and development in emerging technologies report higher levels of innovation and operational efficiency, according to recent research (Meier et al., 2023). For example, giving staff members the know-how to use blockchain systems can result in better data management and decision-making procedures (Ullah et al., 2023). Additionally, competent workers are better able to adjust to technological advancements, which improves supply chain performance as a whole (Agi & Jha, 2023). Blockchain and related technology-focused training programs are essential for developing an innovative and flexible culture. According to Zhang et al. (2023),

companies that prioritize ongoing education are better equipped to handle the intricacies of contemporary supply chains. Furthermore, spending on the well-being of employees is associated with increased levels of engagement, which in turn leads to better performance (Kumar et al., 2023). In order to maximize technology adoption, recent studies emphasize how crucial it is to match training programs with organizational objectives (Soni et al., 2023).

Organizational Readiness as Moderator
The degree to which an organization is equipped to adopt new procedures and technologies is known as organizational readiness. It includes elements like infrastructure, culture, and the accessibility of resources (Teece, 2014).
H5: The relationship between supply chain efficiency and transparency and independent variables (adoption of blockchain technology, stakeholder awareness and education, regulatory framework, and human capital development) is moderated by organizational readiness.

High readiness increases an organization's chances of successfully implementing new technologies, which boosts productivity and transparency (Wong et al., 2023). Stakeholder education and regulatory compliance initiatives are more successful when they are supported by an innovative organizational culture (Madhani, 2021). On the other hand, companies that are not prepared might find it difficult to reap the rewards of blockchain, which could lead to less than ideal performance (Shin et al., 2023).
In order to lower resistance and boost buy-in, research by Ghadge et al. (2023) highlights the significance of evaluating organizational readiness prior to implementing new technologies. A culture of preparedness and flexibility is fostered by effective communication regarding the advantages of new technologies (Yin et al., 2023).

Underpinning Theory Technology-Organization-Environment (TOE) Framework
Tornatzky and Fleischer (1990) created the TOE Framework, which is a well-known model for comprehending the elements affecting technology adoption in businesses. It asserts that the environment, organization, and technology all interact to affect how innovations are adopted and put into practice.
Important Elements of the Technology of the TOE Framework: This component focuses on the features of the technology itself (in this case, blockchain) and how they can improve the transparency and efficiency of the supply chain. Improving operational procedures and traceability are directly linked to the alleged advantages of implementing blockchain technology.
Establishment: This part looks at the organization's internal characteristics, like organizational preparedness and human capital development. It takes into account how the resources, culture, and structure of an organization affect the uptake of new technologies.
Environment: This includes the regulatory framework, stakeholder awareness and education, and the external context in which the organization functions. The incentives and pressures that push businesses to embrace blockchain technology are shaped by the environment.

Technology-Organization-Environment (TOE) Framework: Theory in Practice
With Organizational Readiness acting as a moderator, the Technology-Organization-Environment (TOE) Framework offers an organized method for comprehending the

elements impacting the adoption of new technologies, particularly how they connect to your research variables: Supply Chain Efficiency and Transparency (DV), Blockchain Technology Adoption, Stakeholder Awareness and Education, Regulatory Framework, and Human Capital Development (IVs).

Utilizing the TOE Framework

Technology: The adoption of blockchain technology is essential to this element. The requirements for increased supply chain efficiency and transparency are met by the characteristics of blockchain, including decentralization, transparency, and security. Businesses that use blockchain can improve product traceability, cut down on fraud, and streamline operations—all of which directly lead to increased efficiency.

Organization: In this case, human capital development is very important. A competent workforce is necessary for blockchain technology to be implemented successfully. Initiatives for training and development can improve workers' capacity to use blockchain efficiently, which will improve operational results.

This relationship is moderated by organizational readiness, which assesses how well a company can use blockchain technology. Successful technology adoption increases supply chain efficiency, and it is more likely to occur in organizations with a culture that encourages innovation and sufficient resources.

Environment: In order to shape the external environment, stakeholder awareness and education are essential. Stakeholders are more likely to support blockchain adoption and promote better supply chain collaboration when they are aware of its features and advantages.

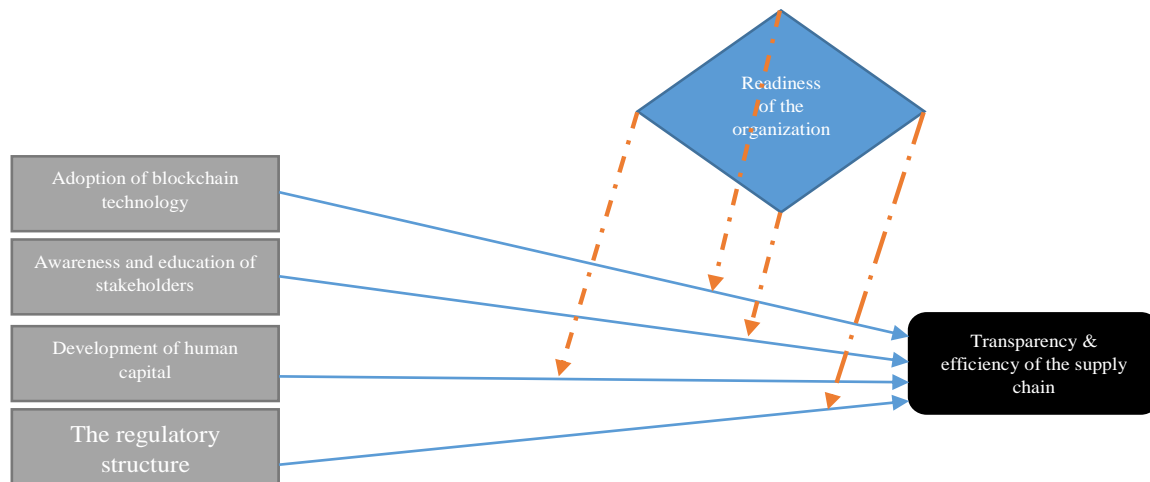## Best fit study variables in the TOE Framework

Adoption of blockchain technology has a direct impact on supply chain transparency and efficiency by facilitating improved tracking, lower costs, and increased partner trust.

Organizational Human Capital Development: Improves operational procedures by strengthening the organization's capacity to successfully apply blockchain technology. The success of blockchain implementation in improving supply chain efficiency is ultimately determined by organizational readiness (moderator), which also affects the efficacy of technology adoption and human capital development.

By creating a welcoming community around the technology, *stakeholder awareness and education (environment)* improves efficiency and collaboration and raises the possibility that blockchain will be adopted.

Transparency in supply chain operations is promoted by the *regulatory framework (environment)*, which offers the required rules and incentives for businesses to implement blockchain.

Conceptual framework

Proposed Research Design

A systematic framework for creating an all-encompassing research methodology is offered by the Saunders Onion Model. Research Philosophy, Research Approach, Research Strategy, Research Choice, Time Horizon, and Data Collection Techniques are the six layers that make up this model. This model's application to your quantitative supply chain efficiency and transparency research is shown below, along with information about the sample and target population.

1. Philosophy of Research

Positivism: The focus of this study will be on observable phenomena and objective measurements, in accordance with positivist philosophy. The objective is to collect measurable information that can be statistically examined to determine correlations between the variables, particularly the effect of blockchain technology and other elements on the transparency and efficiency of the supply chain.

2. Research Approach:

A deductive approach will be used, in which theories that already exist (such as the TOE Framework) will be the basis for the formulation of hypotheses. The study will use quantitative information gathered from surveys to test these theories.

3. Methodology for Research

The main method for gathering data will be a structured survey. In order to statistically analyze the relationships between independent variables (such as stakeholder awareness and blockchain adoption) and the dependent variable (supply chain efficiency and transparency), it is possible to collect standardized data from a large sample.

4. Selection of Research

One-way Quantitative: A mono-method quantitative approach will be used in the study, with an exclusive focus on numerical data derived from survey responses. This decision supports the objective of using statistical techniques to measure variables and test hypotheses.

5. Horizon of Time

Cross-sectional Study: The study will use a cross-sectional time horizon, gathering information at one particular moment in time. This method works well for analyzing how blockchain adoption is currently progressing and how it affects supply chain effectiveness.

6. Methods of Gathering Data

Questionnaire for the Survey: Likert scale items will be included in a structured

questionnaire to gauge opinions about:
Adoption of blockchain technology
Awareness and education of stakeholders
The regulatory structure
Development of human capital
Readiness of the organization
Transparency & efficiency of the supply chain

Target Population
The research's target population will be managers and supply chain experts employed in blockchain-impacted industries. Among the appropriate industries are manufacturing Transportation &Logistics and Food & Drink

Sampling Method and Sample Size
To guarantee representation from a range of sectors within the target population, a stratified random sampling technique will be employed. This method offers a thorough understanding of the variables affecting supply chain efficiency and transparency and enables comparisons across various industries.

The size of the sample

A power analysis will be used to determine the sample size, with a minimum of 300–350 respondents being the goal. This figure will improve the findings' dependability and supply enough data for analysis (Saunder et al., 2016).

Conclusion of the study
The goal of this study was to create a thorough model for comprehending how blockchain technology affects supply chain transparency and efficiency. The goals were well-defined: to investigate the ways in which supply chain performance is impacted by blockchain adoption, stakeholder education and awareness, regulatory frameworks, and human capital development, while also taking organizational readiness into account as a moderating factor. Our goal in conducting this study was to develop a theoretical framework that can be empirically tested in subsequent research projects.
The main variables found in this study are supply chain efficiency and transparency (dependent variable), regulatory framework (independent variable), human capital development (independent variable), blockchain technology adoption (independent variable), and stakeholder awareness and education (independent variable). The degree to which the independent and dependent variables are related is also influenced by organizational readiness, which acts as a moderating variable.
This study determines the anticipated relationships between these variables by formulating five hypotheses. The Technology-Organization-Environment (TOE) Framework, which offers a comprehensive perspective of the elements impacting technology adoption, serves as the theoretical foundation for this investigation. This framework is ideal for analyzing the intricacies of blockchain integration in supply chains because it highlights the interaction between organizational traits, technological capabilities, and environmental factors. By utilizing this theory, the study offers a strong basis for the suggested conceptual framework while also being in line with existing literature.
The suggested model conceptualizes the connections between the variables that have been identified and shows how the adoption of blockchain technology can improve

supply chain transparency and efficiency, subject to organizational readiness. This model emphasizes the significance of raising stakeholder awareness, developing human capital, and creating supportive regulatory environments in addition to acting as a guide for upcoming empirical testing.

In terms of methodology, the study uses a quantitative research design, gathering information from supply chain experts in a range of industries through a cross-sectional survey approach. Standardized data can be gathered through the use of a structured questionnaire, which makes it easier to perform the statistical analysis required to test the hypotheses. To further improve the study's validity and reliability, a stratified random sampling technique is used to guarantee varied representation from industries like manufacturing, logistics, and food and beverage.

The potential contributions of this research to scholarly literature as well as real-world supply chain management applications make it significant.

This study offers practitioners useful insights for navigating the challenges of blockchain adoption by developing a model that incorporates important factors affecting efficiency and transparency. Policymakers can also benefit from the findings by learning about the regulatory frameworks that are required to encourage technological innovation in supply chains.

Implications of the Research

The results of this study on how blockchain technology affects supply chain transparency and efficiency have important ramifications for a number of stakeholders, including academics, practitioners, and policymakers.

1. Useful Consequences for Professionals

a.   Improving the Efficiency of the Supply Chain

The study emphasizes how blockchain technology improves supply chain effectiveness. Practitioners can use this knowledge to put blockchain solutions into place, which can increase traceability, cut expenses, and streamline operations. Businesses looking to improve their supply chain procedures should think about investing in blockchain technology.

b. Need for Stakeholder Education

The results highlight how crucial stakeholder education and awareness are to the successful adoption of blockchain. Training initiatives that inform staff members, vendors, and clients about the features and advantages of blockchain technology must be given top priority by organizations. Businesses can increase cooperation and trust throughout the supply chain by cultivating an informed workforce.

c. Engagement with the Regulatory Framework

According to the study, enabling blockchain integration requires a supportive regulatory environment. Practitioners ought to interact with regulatory agencies in order to support laws that encourage creativity and offer precise instructions for using blockchain technology. An atmosphere that encourages the adoption of technology can be produced with the aid of this involvement.

d. Funding the Development of Human Capital

One of the most important factors affecting supply chain performance is human capital development. Businesses should fund employee education and training initiatives that improve knowledge of data management and blockchain technology. In addition to enhancing operational capabilities, this investment gets the workforce ready for upcoming technological developments.

2. Implications for Policy
a. Policies that Encourage
The study emphasizes how important it is for legislators to create precise legal frameworks that facilitate supply chains using blockchain technology. In order to ensure that regulations promote innovation while safeguarding the interests of consumers, policymakers should work with industry stakeholders to create guidelines that address data privacy, security, and interoperability.

b. Promoting Collaborations between Public and Private Sectors
The results imply that cooperation between the public and private sectors can improve blockchain adoption's efficacy. To exchange information, resources, and best practices about implementing blockchain, policymakers should support collaborations that unite government organizations, business executives, and academic institutions.

3. Implications for Academics
a. Theory Contributions
By using the Technology-Organization-Environment (TOE) Framework in the context of supply chain management and blockchain, this study adds to the body of knowledge already available on technology adoption. This work can be expanded upon by future researchers to examine more aspects of technology adoption and improve on current theoretical frameworks.

b. Empirical Research Foundation
Additional empirical research can be built upon the established hypotheses and suggested conceptual framework. Scholars can investigate the dynamics of organizational readiness over time and evaluate the long-term effects of blockchain adoption on supply chain performance by conducting longitudinal studies.

4. Implications for the Industry
a. Comparing Best Practices
Industry leaders looking to deploy blockchain solutions can use the study's findings as benchmarks. Businesses can find best practices for incorporating blockchain into their supply chains by studying the experiences of early adopters.

b. Promoting Innovation
This study inspires industries to innovate and adjust to shifting market demands by showcasing how blockchain technology can improve efficiency and transparency. Businesses that use blockchain can stand out in crowded markets, increasing client loyalty and satisfaction.

Prospects for the Future
The study's conclusions and ramifications pave the way for a number of future investigations into supply chain management and blockchain technology.

1. Studies with a longitudinal design
Longitudinal studies can be used in future research to evaluate the long-term effects of blockchain adoption on supply chain transparency and efficiency. By tracking changes over time, these studies would give researchers a better understanding of how integrating blockchain technology affects operational performance and flexibility.

2. A Wider Range of Industries
Although the manufacturing, logistics, and food and beverage industries were the focus of this study, future research could broaden the scope to encompass more industries. A thorough analysis of how blockchain adoption may benefit industries like healthcare, retail, and pharmaceuticals is necessary because these sectors may face particular

opportunities and challenges.

3. Examining Other Factors
Additional factors that might affect the connection between supply chain performance and blockchain technology could be investigated in future research. The intricacies of technology adoption may be better understood by taking into account elements like organizational culture, leadership support, technology infrastructure, and external market dynamics.

4. The Effects of New Technologies
Future studies could look into how blockchain technology interacts with other cutting-edge technologies like big data analytics, the Internet of Things (IoT), and artificial intelligence (AI). Gaining insight into how these technologies can work together to improve supply chain transparency and efficiency may result in creative frameworks and solutions for businesses.

5. Creation of Frameworks for Best Practices
The creation of best practice frameworks for supply chain blockchain implementation can be the subject of future research. Researchers can produce practical recommendations that practitioners can adhere to by gathering case studies and success stories from businesses that have successfully implemented blockchain.

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