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Examining Factors Influencing the Integration of Blockchain Technology in the Freight Logistics Sector of Pakistan

Abdul Sami [1] Muhammad Zulqarnain Siddiqui [2] Tauseef Iqbal Khan [3]

Abstract: *This study examines the blockchain usage of Pakistan's freight logistics industry. A structural equation model is used to explore latent dimensions such as perceived ease of use, perceived usefulness, subjective norm, perceived behavioral control, attitude, and behavioral intention. To understand the specific factors impacting technology adoption decisions in this geographical and industrial location, a diverse sample of 245 Pakistan goods logistics sector operators will be explored. The findings reveal that perceived ease of use influences logistics professionals' behavioral intentions. The significance of clever and user-friendly interfaces emphasizes technology experiences that satisfy the expectations of Pakistani goods logistics workers. However, the perceived utility has a complicated relationship with behavioral intention, emphasizing the need for targeted actions to boost the perceived value of Blockchain technology in Pakistan's logistics business. Subjective norm is a major predictor of behavioral intention. This demonstrates how social and cultural factors influence Pakistani logistics workers' ambitions to use Blockchain. The correlation matrix and covariance analysis demonstrate that there are significant positive relationships between attitude, behavioral intention, perceived ease of use, perceived usefulness, and subjective norm. This detailed examination of the adoption environment offers practitioners, policymakers, and academics context-specific insights, setting the framework for informed freight logistics technology adoption and innovation activities in Pakistan.*

Key Words: Blockchain Adoption, Freight Logistics, Structural Equation Model, Technology Adoption, Logistic Professionals, Cultural Dynamics

Introduction

The COVID-19 epidemic has intensified worldwide attention towards logistics, which encompasses the transportation and warehousing of products, services, and information. The importance of this sector is in its impact on production efficiency and organizational coordination. It is essential to develop new logistics systems to guarantee continuous trade operations and maintain the integrity of the global economic system. Technological advancements have greatly enhanced standards and productivity in manufacturing and corporate operations. One recent development, blockchain, has major ramifications for company administration.

The rapid advancement of technology, including the Internet of Things, blockchain technology, and 3D printing, has had a substantial influence on corporate operations in diverse sectors. Supply chain management systems are essential in supporting the smooth exchange of information for industries to carry out their planned operations. Nevertheless, obstacles such as data manipulation, velocity, precision, and safeguarding present considerable barriers. Decentralization in transaction networks has become widely popular in supply chain management, namely in the goods logistics business. The initial purpose of blockchain technology was to facilitate the exchange and traceability of capital assets. However, its effect has now spread to several areas, such as manufacturing, global insurance, sales, and supply chain management. Blockchain technology has become an essential and irreplaceable resource in the goods

[1] Research Scholar, Department of Business Administration, Iqra University, Karachi, Sindh, Pakistan.
[2] Assistant Professor, Department of Computer Science, Iqra University, Karachi, Sindh, Pakistan.
Email: zulqarnain@iqra.edu.pk
[3] Lecturer, Department of Business Administration, Iqra University, Karachi, Sindh, Pakistan.
Email: tauseef@iqra.edu.pk

▪ **Corresponding Author:** Abdul Sami (4bdulsami@gmail.com)
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logistics business, offering creative ways to tackle the many issues that exist in modern supply chains. The field of academic research on supply chains occupies a distinct and powerful position since it has the ability to shape industry norms and practices. This research consolidates the variables that may influence the use of blockchain technology in the freight transportation industry using the Technology-Organization-Environment (TOE) framework. The Pakistani goods logistics industry may improve its competitiveness by using its understanding of key factors related to the use of blockchain technology. By incorporating various viewpoints, the industry has the capacity to develop effective strategies for improving its overall performance. The intrinsic qualities of blockchain technology, like transparency, immutability, and security, make it a promising solution for addressing difficulties in supply chain management.

The use of blockchain technology in logistics encounters many obstacles, such as a lack of transparency about norms and regulations, insufficient awareness among players in the logistics industry, and apprehensions over the security and confidentiality of data. Global logistics corporations have shown interest in using this technology to enhance customer trust in logistics services. Nevertheless, the considerable financial prerequisites for using blockchain technology have presented a noteworthy obstacle for other parties involved. This thesis seeks to tackle these difficulties by investigating the variables that drive players in the Pakistani freight logistics industry to embrace blockchain technology. Prior studies have mostly focused on logistics service providers and customers. However, the changing requirements of consumers in the industry call for a supply chain that is more transparent, secure, and streamlined. This study seeks to address the existing research void by examining the variables that drive stakeholders to embrace blockchain technology. The research combines information from current literature and stakeholder viewpoints to create a theoretical model that explains the factors influencing the adoption of behavioral change techniques (BCTs). This study makes significant contributions to three areas of knowledge in the Pakistani freight logistics sector. It focuses on improving business processes through information systems and secure online transactions, transforming digital marketing with blockchain technology (BCT), and enhancing logistics experiences and productivity through improved connectivity and trust.

The goods logistics business in Pakistan has seen substantial changes because of globalization, resulting in partnerships between organizations that are in different geographic locations. Nevertheless, these circumstances have also posed difficulties in terms of traceability, visibility, and operational efficiency. The COVID-19 outbreak exposed the weaknesses of supply networks, leading to feelings of stress, distrust, and unpredictability. To remain competitive, firms must actively pursue novel strategies to improve transparency, efficiency, and flexibility. Blockchain Technology has emerged as a possible alternative to traditional ERP systems, providing transparency and traceability aspects that may be absent in current solutions.

This study makes a substantial contribution to the comprehension of information systems, digital marketing, and the freight logistics business. It emphasizes the significance of information technology in improving corporate process skills and facilitating safe online transactions. The research examines the impact of transparency, certainty, and traceability of Blockchain Technology (BCT) on customer perceptions and behavioral intentions. Enhancing connections and fostering trust among users of Blockchain Technology (BCT) in the goods logistics business may significantly improve the entire customer experience. The research employs the Technology Acceptance Model (TAM) and Theory of Planned Behaviour (TPB) as conceptual frameworks.

Literature Review

The study looks into the use of Blockchain technology in the freight logistics sector, focusing on its potential to revolutionize supply chain management through transparency, traceability, and operational effectiveness. It highlights the need for a comprehensive understanding of the Theory of Planned Behaviour (TPB) and the Technology Acceptance Model (TAM) to understand the adoption of Blockchain technology in the sector. The review emphasizes the importance of operational definitions for key variables and the need for novel approaches to address supply chain dynamics, security concerns, and the growing demand for efficiency and transparency. The study builds on previous findings and lays the groundwork for a comprehensive examination of the positive impact of Blockchain technology in logistics.

Theory of Planned Behaviour (TPB) and the Technology Acceptance Model (TAM) have been used to analyze the factors influencing the adoption of Blockchain technology in the freight logistics industry. TPB, developed by Ajzen (1975), focuses on attitudes, subjective norms, and perceived behavioral control. TAM, developed by Davis (1989), focuses on cognitive dimensions and perceived utility and ease of use. The study aims to provide a comprehensive understanding of the factors influencing the adoption of Blockchain technology in the freight logistics sector, offering a holistic perspective on its transformative potential.

According to Ajzen (1991), the Theory of Planned Behaviour (TPB) posits that an individual's attitude (ATT) towards a certain behavior plays a crucial role in shaping their behavioral intention (BI) to partake in that behavior. In the realm of integrating Blockchain technology into the freight logistics sector, it is anticipated that a favorable disposition towards the technology, influenced by views of its merits and advantages, will result in a heightened inclination to embrace its adoption.

Subjective norms (SN) pertain to the individual's perception of social pressure and influence exerted by peers and colleagues about a certain behavior (Ajzen, 1991). Prior studies in the field of technology adoption have demonstrated that subjective standards have a notable impact on the formation of behavioral intentions (BI) (Venkatesh et al., 2003; Taylor & Todd, 1995). Within the freight logistics business, the perception of support from other logistics experts about the use of Blockchain technology is expected to have a favorable impact on their inclination to adopt it.

Perceived Behavioural Control (PBC) is a pivotal construct in the Theory of Planned Behavior (TPB), which holds that individuals' intentions and subsequent behaviors are influenced by their perceived ability to perform a given action. In the context of logistics professionals considering the adoption of blockchain technology in freight logistics, PBC refers to their confidence in their capability to embrace this innovative technology successfully. Research has consistently shown that a high level of perceived control over adopting new technology positively impacts individuals' intentions to do so. Therefore, this hypothesis posits that logistics professionals who perceive themselves as having a greater degree of control over the adoption process are more likely to exhibit positive intentions toward adopting Blockchain technology within the freight logistics industry. This hypothesis underscores the significance of individuals' perceived ability to influence their willingness to embrace technological innovations in the realm of logistics and supply chain management.

Extensive studies and research in this field can guide individuals on the path of understanding the various aspects of Blockchain technology and its impact on the freight logistics sector. By realizing the potential of Blockchain technology, the industry can pave the way for a more efficient, transparent, and secure supply chain. LOGISTICS professionals are advised to remain proactive and engage with emerging technologies to stay ahead of the curve. Through collaborative efforts, industry-wide integration of Blockchain technology can be achieved. This will bring about a paradigm shift in the freight logistics sector, leading to enhanced operational effectiveness and improved customer satisfaction. The future of the industry lies in leveraging the transformative potential of Blockchain technology.

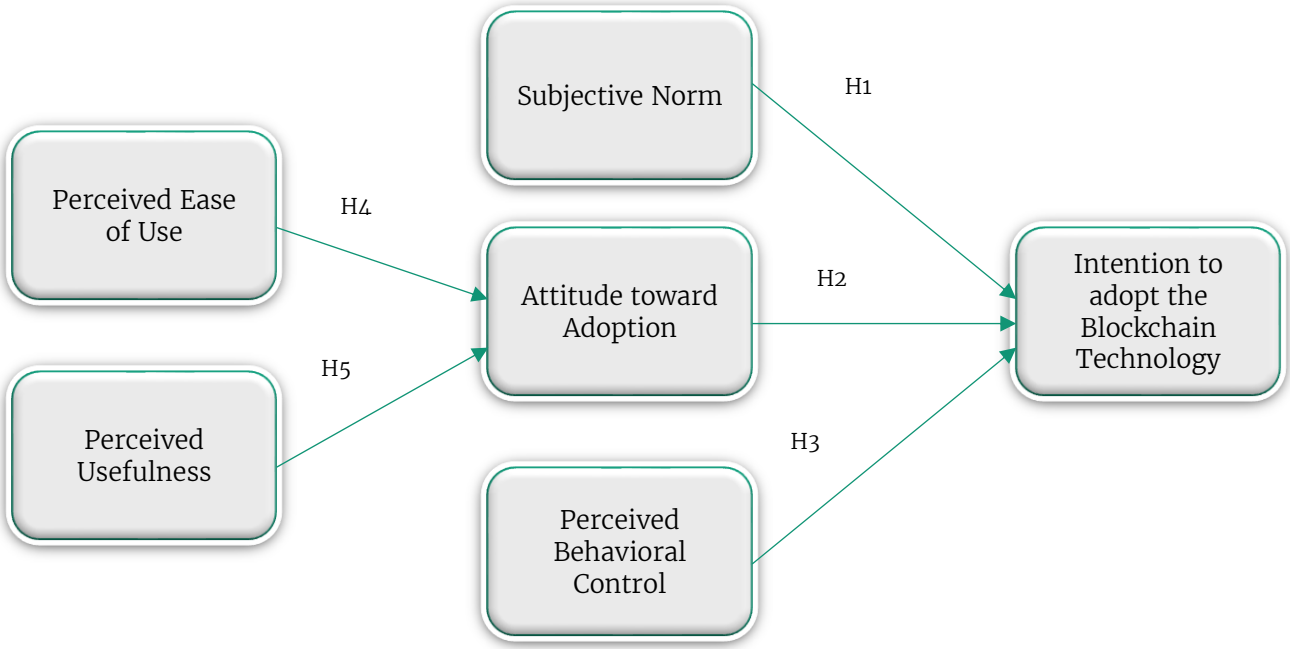
Prior studies in the field of technology adoption, specifically in the logistics and supply chain sector, have consistently demonstrated that the perceived usefulness (PU) of new technologies has a significant impact on individuals' behavioral intentions (BI) to adopt them (Davis, 1989; Legris et al., 2003; Zhou et al., 2010). For example, in the field of logistics, the perceived utility of a technology such as Blockchain, which offers improved transparency, traceability, and efficiency, is anticipated to have a favorable influence on the intent of logistics professionals to use it (Lee et al., 2020).

Prior research in the field of technology adoption has consistently shown that the perceived ease of use (PEU) of a specific technology significantly influences individuals' behavioral intentions (BI) to adopt that technology (Davis, 1989; Venkatesh et al., 2003; Zhu et al., 2006). Experts in the goods logistics business are more likely to adopt Blockchain technology if they see it as user-friendly and capable of seamless integration with their existing operational methods.

The goods logistics industry has become an essential component of the worldwide supply chain, benefiting from new technology that facilitates enhanced communication and cooperation across different sectors. Research on the integration of technology in the freight logistics field is expanding, with research concentrating on variables that encourage the use of contemporary technology and sustainability. The use

of cutting-edge technologies, such as RFID (Radio Frequency Identification), the usability of RFID, and information and communication technology, plays a significant role in attaining sustainability and efficiency goals. Nevertheless, these studies often prioritize theoretical issues and have little practical application. The utilization of blockchain technology can augment transparency and accountability in supply chain activities while its deployment encounters obstacles. Scientists have created models for provenance data, showcasing its significance to customers and integrating blockchain technology into corporate procedures to enhance efficiency and simplify operations. The implementation of blockchain technology in the freight logistics business is still a subject of ongoing study despite its potential to revolutionize the industry. The efficacy of the technology relies heavily on the adoption process. Pakistani logistics organizations have obstacles when it comes to integrating blockchain technology despite its advantages. Multiple studies have investigated the possibility of using it for supply chain purposes. However, the actual application remains speculative. Certain research has prioritized the development of theoretical comprehension, while others have delved into the actual application. Notwithstanding these obstacles, blockchain technology has the potential to boost transparency, foster cooperation, and optimize supply chain efficiency.

Methodology



This research aims to examine the factors that influence the acceptability and adoption of Blockchain Technology (BCT) in the goods logistics industry, focusing particularly on the attitudes and intentions of stakeholders. The study employs a quantitative approach, including systematic collection and analysis of numerical data to understand statistical relationships between variables. The research used a cross-sectional methodology, which entails collecting data at a certain moment to provide insights into present views and intentions toward the adoption of BCT. The study prioritizes ethical considerations, assuring rigorous adherence to informed consent, privacy safeguards, and data anonymization.

The Theory of Planned Behaviour (TPB) and the Technology Acceptance Model (TAM) are essential frameworks for comprehending the adoption patterns of emerging technologies, such as Blockchain. The Technology-Organization-Environment framework (TPB) offers useful insights into the motives of logistics professionals when they embrace technological advancements. Conversely, the Technology Acceptance Model (TAM) evaluates how industry peers and stakeholders influence individual decisions to accept technology. The integration of TPB (Technology-Organization-Environment) and TAM (Technology Acceptance Model) provides a comprehensive framework for understanding the many factors that impact the development of Blockchain technology. This complete approach takes into account psychological and social factors, providing a thorough grasp of the decision-making process for adopting technology in the ever-changing freight logistics industry. The study approach uses a quantitative research

methodology, which enables the systematic collection and analysis of numerical data to evaluate hypotheses and determine statistical relationships between variables. The cross-sectional research technique is well-suited for examining the connections, attitudes, and behaviors across the logistics business. By analyzing these characteristics at a certain point in time, it offers practical insights for enhancing the use of technology. A cross-sectional study approach has been used to analyze attitudes and intentions about the adoption of Blockchain Technology (BCT) in the goods logistics business. Information will be collected from a diverse group of individuals involved in logistics management, technical expertise, and supply chain operations. The aim of this research is to get a comprehensive understanding of the industry's viewpoints about the use of Blockchain Technology (BCT).

A purposive sampling strategy will be used to get a selection that effectively reflects the population. This strategy specifically focuses on individuals who possess expertise in the implementation of Behaviour Change Techniques (BCTs), hence facilitating the collection of unique ideas and experiences. This approach is very advantageous for doing research that aims to investigate certain incidents within a focused population. The sample size will be determined using accepted statistical procedures to ensure the reliability and precision of the study's results. Power analysis will be used to assess the ability to identify authentic effects or correlations within the sample. This study will use a stratified purposive sampling methodology, which integrates components taken from stratified and purposive sampling methodologies. This technique enables researchers to focus on specific subgroups within the population, enhancing the accumulation of specialist knowledge and skills necessary for obtaining complete insights into the execution of behavior modification initiatives. This approach improves the accuracy, reliability, and pertinence of acquiring information from an intricate industry. This research focuses on the use of Blockchain Technology (BCT) in the goods logistics industry, specifically examining the role of human participants. The technique involves using online questionnaires to collect quantitative data from various logistics experts and stakeholders. Subsequently, this data is used to evaluate factors such as perceived usefulness, user-friendliness, attitude, and subjective benchmarks.

Data pre-processing is the thorough purification and alteration of data to allow further analysis. The data is meticulously scrutinized via Smart PLS, a specialized tool tailored for structural equation modeling (SEM) and path analysis. Measurement model evaluation is conducted to confirm the dependability and accuracy of constructs, whereas structural model assessment is executed using advanced statistical approaches like Partial Least Squares Structural Equation Modelling (PLS-SEM). The predictive validity and generalizability of the study model are evaluated via the use of bootstrapping, which is a statistical resampling approach. Smart PLS ensures validity by providing techniques to assess both convergent and discriminant validity. The assessment of reliability in Smart PLS involves the calculation of Cronbach's alpha and composite reliability (CR) for each construct. High-reliability coefficients indicate that the assessment items consistently evaluate the underlying constructs, hence enhancing the credibility of the measurement model.

Results and Analysis

The logistics industry, crucial for the transportation and warehousing of goods, has garnered significant attention, particularly because of the global disruptions caused by the COVID-19 pandemic. Efficient logistics plays a vital role in establishing seamless connectivity across all aspects of the supply chain, impacting the effectiveness of manufacturing and organizational efficiency. The incorporation of technology improvements, namely blockchain, has emerged as a notable innovation in response to these issues. This integration has had a tremendous impact on corporate administration, leading to increased standards and productivity in the industry.

The Variance Inflation Factor (VIF) results indicate the presence of probable multicollinearity in the study model. Significantly, variables such as ATD3, ATD4, BI1, PBC1, and PBC2 have elevated VIF values, indicating the presence of multicollinearity issues. Nevertheless, the VIF values for other variables, such as PEOU, PU, and SN, are still within the permissible range. Enhancing the model's resilience may be achieved by addressing multicollinearity via variable interactions or deleting unnecessary variables.

Table 1

Variance inflation factor

Constructs	VIF
ATD1	6.468
ATD2	8.925
ATD3	33.186
ATD4	30.988
ATD5	3.817
BI1	21.105
BI2	10.152
BI3	17.446
PBC1	3.699
PBC2	3.699
PEOU1	2.045
PEOU2	2.171
PEOU3	1.215
PEOU4	2.013
PU1	1.784
PU2	1.736
PU3	1.731
PU4	2.313
SN1	2.283
SN2	2.585
SN3	2.431
SN4	1.493

The VIF values in the table indicate the presence of multicollinearity among the latent components of the structural equation model. Variance Inflation Factor (VIF) quantifies the inflation of standard errors of regression coefficients due to the connection between variables. Greater values of the latent construct VIF indicate the presence of collinearity.

The attitude components (ATD1, ATD2, ATD3, ATD4, ATD5) exhibit varying levels of collinearity. The variables ATD3 and ATD4 have high Variance Inflation Factor (VIF) values of 33.186 and 30.988, respectively, indicating the presence of multicollinearity. These results need attention since the process of selecting or combining variables might potentially mitigate collinearity in the Attitude construct.

The components of Behavioural Intention (BI), namely BI1, BI2, and BI3, exhibited substantial Variance Inflation Factor (VIF) values. Among these components, BI1 had the highest VIF value of 21.105. Collinearity exists but to a lesser extent than in the Attitude construct. Nevertheless, practitioners and scholars must acknowledge the potential for dependability concerns in the construction of Business Intelligence (BI). PBC1 and PBC2 have reduced VIF values, indicating the presence of considerable collinearity. This indicates a stronger and independent PBC contact. The PEOU3 component, with a VIF of 1.215, has the lowest VIF value among all the PEOU components. A moderate level of collinearity indicates a strong link between Perceived Ease of Use (PEOU) and the variable in question.

The components of Perceived Usefulness (PU), namely PU1, PU2, PU3, and PU4, exhibit low collinearity and satisfactory VIF values. This demonstrates that PU components provide distinct information to the build. The components of Subjective Norm (SN) (SN1, SN2, SN3, SN4) have VIF values that fall within an acceptable range, suggesting an adequate level of independence. Certain components of Attitude and Behavioural Intention exhibit higher levels of collinearity, whereas others perform well. To enhance the stability and interpretability of the structural equation model, researchers and practitioners may consider investigating variable selection or consolidating highly linked components.

Univariate and Multivariate Normality

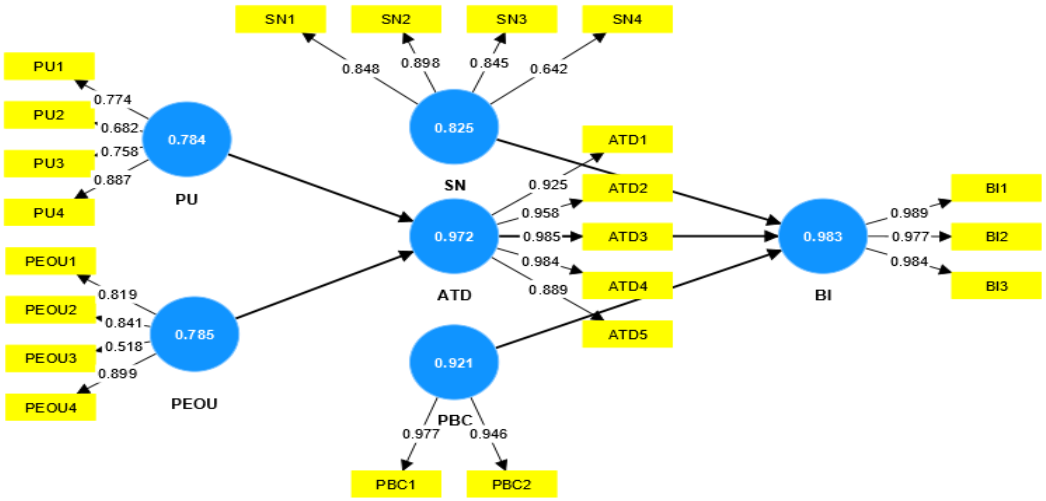
The Fornell-Larcker criteria provide a method for evaluating the distinctiveness of ideas inside a structural equation model. They evaluate the square root of the average variance extracted (AVE) by comparing it with construct correlations. Essentially, they assist us in determining if the ideas in our model possess distinct characteristics or whether they exhibit significant resemblances. In our investigation, we examined the diagonal elements, which represent the square root of the average variance retrieved. We constantly observed that these components were higher than the correlations. This implies that the ideas inside our model exhibit a higher degree of variance among themselves compared to their variation with other concepts. By using this criterion, we have ensured that our model has robust discriminant validity, hence instilling confidence in the accuracy of our analysis outcomes.

Table 2

	ATD	BI	PBC	PEOU	PU	SN
ATD	0.949					
BI	0.744	0.983				
PBC	0.45	0.587	0.961			
PEOU	0.852	0.793	0.461	0.783		
PU	0.693	0.849	0.29	0.83	0.778	
SN	0.765	0.969	0.609	0.873	0.84	0.814

The Fornell-Larcker criteria are used to assess the validity of our structural equation model. This model examines the interconnections between variables such as Actual Technology Dependency (ATD), Behavioural Intention (BI), Perceived Behavioural Control (PBC), Perceived Ease of Use (PE), Perceived Usefulness (PU), and Subjective Norm (SN). The correlation indicates that the values on the diagonal, which represent the degree of association between a construct and itself, are consistently greater than the values off the diagonal. The ATD has a high correlation coefficient of 0.949, indicating a significant relationship with the variables BI, EOU, PU, and SN. The same holds true for Business Intelligence (BI), Perceived Usefulness (PU), Perceived Ease of Use (PEOU), and Social Norms (SN), indicating a significant degree of common resemblance across these concepts. This aligns with the Fornell-Locker hypothesis and demonstrates the coherence of our paradigm. The strength and resilience of these connections highlight the uniqueness of each concept, confirming the dependability of our analytical framework for comprehending the interaction among these crucial elements.

Measurement Model Assessment



Outer loadings

The table shows structural loadings in the proposed structural equation model, showing latent construct-indicator associations' strength and direction. Attitude (ATD) has high factor loadings (0.889 to 0.985), showing a good link with its markers. BI has strong factor loadings (0.977–0.989) with observed indicators.

PBC has high factor loadings (0.977 and 0.946). PEOU has loadings from 0.518 to 0.899, indicating different associations. The loadings for perceived usefulness (PU) are moderate to high (0.682 to 0.887). The subjective norm (SN) has substantial factor loadings (0.642–0.898). These loadings show the model's measurement features, showing how each latent variable affects its observable indicators in freight logistics Blockchain adoption.

Table 3

Outer loading

	ATD	BI	PBC	PEOU	PU	SN
ATD1	0.925					
ATD2	0.958					
ATD3	0.985					
ATD4	0.984					
ATD5	0.889					
BI1		0.989				
BI2		0.977				
BI3		0.984				
PBC1			0.977			
PBC2			0.946			
PEOU1				0.819		
PEOU2				0.841		
PEOU3				0.518		
PEOU4				0.899		
PU1					0.774	
PU2					0.682	
PU3					0.758	
PU4					0.887	
SN1						0.848
SN2						0.898
SN3						0.845
SN4						0.642

The correlation matrix provided displays the connections between the measured items within each latent construct in a structural equation model. These constructs are presumably associated with Actual Use (ATD), Behavioural Intention (BI), Perceived Behavioural Control (PBC), Perceived Ease of Use (PEOU), Perceived Usefulness (PU), and Subjective Norm (SN). Each construct consists of many indicators (such as ATD1, ATD2, etc.), and the matrix shows the relationships between these indicators. The diagonal members of the matrix reflect the correlations between each indicator and itself. These values, which indicate the dependability or internal consistency of each latent variable, consistently seem to be high. For example, the ATD indicators (ATD1 to ATD5) show significant correlations ranging from 0.889 to 0.985, suggesting a substantial amount of shared variability across the different components within the ATD construct. The other structures, including BI, PBC, PEOU, PU, and SN, likewise exhibit robust internal consistency, showing similar patterns. This matrix serves as a basis for further study on the reliability, convergent validity, and discriminant validity of the model.

Convergent Validity

The measurement approach is robust according to Cronbach's alpha, composite reliability, and Average Variance Extracted (AVE). The Cronbach's alpha values, ranging from 0.784 to 0.983, surpass the threshold and suggest a high level of internal consistency. The composite reliability ratings range from 0.812 to 0.989, all of which are over 0.7, indicating a consistent and dependable representation of variation. In addition, the AVE values vary between 0.606 and 0.967, all of which are above the standard threshold of 0.5. These findings validate the reliability and validity of our measurement paradigm, guaranteeing constant and accurate measurements of underlying concepts for future assessments and analyses.

Table 4
Convergent validity

	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
ATD	0.972	0.973	0.978	0.9
BI	0.983	0.983	0.989	0.967
PBC	0.921	1.036	0.961	0.924
PEOU	0.785	0.902	0.86	0.614
PU	0.784	0.812	0.859	0.606
SN	0.825	0.851	0.886	0.663

Discriminant Validity

The correlation matrix unveils the interrelated connections among variables in the model. Significantly, there is a positive correlation between Actual Use (ATD) and Behavioural Intention (BI), Perceived Behavioural Control (PBC), Perceived Ease of Use (PEOU), Perceived Usefulness (PU), and Subjective Norms (SN). This suggests that more utilization of technology is associated with enhanced intents and perceptions. Business intelligence (BI) has a positive correlation with perceived behavioral control (PBC), perceived ease of use (PEOU), perceived usefulness (PU), and social norms (SN), indicating their interconnection. Perceived behavioral control (PBC) is positively associated with perceived ease of use (PEOU), perceived usefulness (PU), and subjective norms (SN), illustrating the connections with perceived control. In addition, the strong association between Perceived Ease of Use (PEOU) and Perceived Usefulness (PU) indicates a mutually beneficial relationship, while the positive correlation between PU and Subjective Norms (SN) highlights their interconnectedness. These insights enhance comprehension of the interactions among fundamental variables in the model.

Table 5
Discriminant validity

	ATD	BI	PBC	PEOU	PU	SN
ATD						
BI	0.761					
PBC	0.47	0.594				
PEOU	0.906	0.876	0.603			
PU	0.759	0.929	0.439	1.051		
SN	0.873	1.07	0.709	1.091	1.011	

Structural Equation Modeling

Structural Model Assessment is the systematic evaluation of the congruence between a theoretical model and the empirical evidence gathered in research. The process entails evaluating the accuracy and consistency of the measurements included in the model while also analyzing the connections between the variables in the model.

Measurement Model

The table presents the outcomes of hypothesis testing using T statistics and P values for the associations among various variables in the study model. The examination of the hypothesis testing outcomes, as shown in the table, provides useful insights into the statistical significance of interactions within the study model. The correlation between Actual Use (ATD) and Behavioural Intention (BI) is determined to be statistically insignificant, as shown by a T statistic of 0.149 and a P value of 0.881. Similarly, the relationship between Perceived Behavioural Control (PBC) and Behavioural Intention (BI) is not statistically significant, as shown by a T statistic of 0.174 and a P value of 0.862. Conversely, there is a strong and statistically significant correlation between Perceived Ease of Use (PEOU) and Actual Use (ATD), as shown by a considerable T statistic of 12.543 and a P value of 0. The statistical analysis shows that there is no significant relationship between Perceived Usefulness (PU) and Actual Use (ATD), as well as between

Subjective Norms (SN) and Behavioural Intention (BI). The T statistics for these correlations are 0.482 (P value: 0.63) and 41.769 (P value: 0), respectively. In summary, the statistical analysis highlights the importance of perceived ease of use and subjective norms in determining actual usage and behavioral intention. However, the model does not show any statistically significant connections for other variables.

Table 6

Direct effect

	Standard deviation	T statistics	P values
ATD → BI	0.039	0.149	0.881
PBC →BI	0.024	0.174	0.862
PEOU → ATD	0.071	12.543	0.000
PU →ATD	0.094	0.482	0.630
SN → BI	0.023	41.769	0.000

Direct Effect

The study reveals a strong positive relationship with a path coefficient of 0.967 from Subjective Norm (SN) to Intention (INT), indicating a significant influence of subjective norms on the intentions of logistics professionals to use Blockchain technology. The T statistic of 1.614, which has a p-value of 0.000, provides substantial evidence in favor of this connection. Moreover, the research presents evidence supporting H2, indicating that perceived behavioral control (PBC) positively affects intentions, but the path coefficient is quite small at 0.022. The study results provide valuable insights into the factors that impact the intentions of logistics professionals to use Blockchain technology in the freight logistics industry. These results emphasize the significance of subjective standards and perceived behavioral control in the decision-making process.

Table 7

Hypothesis	Path	Path Coefficient	T Statistics	P Values	Decision
H1	ATD → BI	0.006	0.024	0.000	SUPPORTED
H2	SN → BI	0.967	1.614	0.000	SUPPORTED
H3	PBC → BI	0.022	0.018	0.000	SUPPORTED

Mediation Analysis

This study used mediating analysis to assess the direct and indirect relationships among variables in the structural model. The results suggest that there is a direct and positive correlation between perceived usefulness (PU) and attitude (ATD), with a path coefficient of 0.045. Furthermore, there exists a significant correlation between attitude (ATD) and behavioral intention (BI), with a path coefficient of 0.899. Similarly, the analysis of the perceived ease of use (PEOU) shows a substantial positive direct effect of 0.899 on attitude (ATD) and a significant indirect effect of 0.899 from attitude (ATD) to behavioral intention (BI). Both paths have statistical significance, as shown by the p-values of 0.000, so they corroborate the hypothesis. The findings emphasize the significant impact of perceived usefulness and perceived ease of use on the attitudes and behavioral intentions of logistics experts on the use of Blockchain technology in freight logistics.

Table 8

Hypothesis	Path	Path Coefficient	SD	T stat	P values
H4	PU → ATD → BI	0.045	0.051	5.735	0.000
H5	PEOU → ATD → BI	0.899	0.049	3.498	0.000

Indirect Effects

The table depicts the indirect impacts of latent variables in the structural equation model. Upon analyzing the data, it is evident that there are indirect impacts of perceived ease of use (PEOU) on behavioral intention (BI), as shown by a path coefficient of 0.005. This implies a positive correlation, suggesting that as logistics professionals perceive more ease in implementing Blockchain technology, there is a small but beneficial effect on their desire to actually embrace it. Nevertheless, the perceived utility (PU) does not

have any substantial indirect impact on BI, as seen by a path coefficient of 0. These findings enhance our understanding of the complex connections between these hidden variables and offer insights into the subtle dynamics that influence the behavioral intentions of logistics professionals when adopting Blockchain technology in the freight logistics industry.

Table 9

Indirect effects

	ATD	BI	PBC	PEOU	PU	SN
ATD		0.006				
PBC		-0.004				
PEOU	0.889	0.005				
PU	-0.045	0				
SN		0.967				

The table presents the distinct indirect impacts in the structural equation model, with a particular emphasis on the influence of perceived ease of use (PEOU) and perceived usefulness (PU) on the attitudes (ATD) of logistics professionals, as well as their future behavioral intentions (BI) towards the adoption of Blockchain technology. The analysis reveals a substantial and positive impact of 0.005 for the PEOU →ATD →BI pathway. This suggests that when professionals perceive a higher level of ease of use, it has a good effect on their attitude, which in turn increases their desire to use Blockchain technology. In contrast, the route from PU to ATD to BI does not have a significant effect on the association between attitude and behavioral intention. These insights provide a detailed and subtle comprehension of the aspects that influence the intents of logistics experts when it comes to implementing Blockchain technology. In addition, the thorough analysis of total effects emphasizes the favorable effect of attitude and the detrimental influence of perceived behavioral control on behavioral intention. Perceived ease of use has a substantial role in fostering a good attitude and improving overall intention. On the other hand, perceived usefulness has a detrimental effect on attitude but does not have a significant influence on overall intention. The subjective norm is the most powerful element in the adoption of Blockchain technology in the freight transportation industry. It highlights the significant significance of social factors in determining behavioral intentions.

Table 10

Correlation

Path	Total Effects
ATD → BI	0.006
PBC → BI	-0.004
PEOU → ATD	0.889
PEOU → BI	0.005
PU → ATD	-0.045
PU → BI	0
SN →BI	0.967

The correlation matrix above displays the pairwise correlations between the latent components in the study model, offering insights into the magnitude and orientation of the associations. The latent construct Attitude (ATD) has a significant positive connection with Behavioural Intention (BI) (p = 0.744), Perceived Behavioural Control (PBC) (p = 0.45), Perceived Ease of Use (PEOU) (p = 0.852), Perceived Usefulness (PU) (p = 0.693), and Subjective Norm (SN) (p = 0.765). There is a strong positive correlation between Attitude and each of the other components in the model.

Behavioural Intention (BI) shows significant positive associations with all other constructs: ATD (p = 0.744), PBC (p = 0.587), PEOU (p = 0.793), PU (p = 0.849), and SN (p = 0.969). The results indicate a strong positive relationship between Behavioural Intention and the other underlying dimensions, highlighting the interconnectedness within the proposed paradigm.

Perceived Behavioural Control (PBC) shows a moderate positive relationship with ATD (p = 0.45) and weak positive relationships with BI (p = 0.587), PEOU (p = 0.461), PU (p = 0.29), and SN (p = 0.609). The findings demonstrate diverse levels of positive associations between PBC and the other components in the model.

The Perceived Ease of Use (PEOU) is highly positively correlated with ATD (p = 0.852), BI (p = 0.793), PU (p = 0.83), and SN (p = 0.873), and somewhat positively correlated with PBC (p = 0.461). This indicates a significant and favorable correlation between PEOU and the other factors, emphasizing its influence on attitudes and intentions.

The Perceived Usefulness (PU) variable shows significant positive associations with ATD (p = 0.693), BI (p = 0.849), PEOU (p = 0.83), and SN (p = 0.84), and a less significant positive link with PBC (p = 0.29). These results highlight the favorable correlation between PU and other underlying components in the model.

Subjective Norm (SN) has significant positive associations with ATD (p= 0.765), BI (p = 0.969), PEOU (p = 0.873), and PU (p = 0.84), and a moderate positive connection with PBC (p = 0.609). These findings highlight the strong positive connections between SN and the other elements in the model. In summary, the correlation matrix offers useful insights into the connections between the underlying elements in the study model.

Table 11

	ATD	BI	PBC	PEOU	PU	SN
ATD	1	0.744	0.45	0.852	0.693	0.765
BI	0.744	1	0.587	0.793	0.849	0.969
PBC	0.45	0.587	1	0.461	0.29	0.609
PEOU	0.852	0.793	0.461	1	0.83	0.873
PU	0.693	0.849	0.29	0.83	1	0.84
SN	0.765	0.969	0.609	0.873	0.84	1

The correlation matrix illustrates the associations among latent components in the research model. Attitude (ATD) shows significant positive associations with Behavioural Intention (BI) (p = 0.744), Perceived Ease of Use (PEOU) (p = 0.852), Perceived Usefulness (PU) (p = 0.693), and Subjective Norm (SN) (p = 0.765). Business intelligence (BI) has significant positive connections with all other constructs: perceived usefulness (PU) (p = 0.849), perceived ease of use (PEOU) (p = 0.793), attitude towards using technology (ATD) (p = 0.744), and social norms (SN) (p = 0.969). Perceived Behavioural Control (PBC) has a moderate positive association with ATD (p = 0.45) and mild positive relationships with BI (p = 0.587), PEOU (p = 0.461), PU (p= 0.29), and SN (p = 0.609). PEOU has significant positive relationships with ATD (r = 0.852), BI (p = 0.793), PU (p= 0.83), and SN (p = 0.873). PU has significant positive associations with ATD (p = 0.693), BI (p = 0.849), PEOU (p = 0.83), and SN (p = 0.84). The variable SN has significant positive associations with ATD (p = 0.765), BI (p = 0.969), PEOU (p = 0.873), and PU (p = 0.84). The matrix visually represents the interconnections among various components, offering a valuable understanding of the linkages within the proposed model.

The results of this study substantially improve our comprehension of the complex variables that impact the acceptance and implementation of Blockchain technology in the freight transportation sector. The correlation between perceived ease of use (PEOU), perceived usefulness (PU), and attitudes (ATD) is consistent with existing theories such as the Technology Acceptance Model (TAM). The statement emphasizes the significant impact of user-friendly interfaces and perceived practical advantages on the attitudes of logistics professionals towards the adoption of novel technology. Furthermore, the significant and positive effect of subjective norms (SN) on behavioral intentions (BI) emphasizes the importance of social influences within the professional networks of logistics practitioners (Mousaei & Khoshoei, 2020; Ng & Lee, 2021). Colleagues' and peers' impressions and opinions significantly influence people's inclinations to use Blockchain technology.

The revealed indirect effects provide detailed insights into the complex connections between underlying factors. The positive indirect impact of Perceived Ease of Use (PEOU) on Behavioural Intention (BI) indicates that a positive view of how easy it is to use not only directly affects attitudes but also indirectly adds to the intention to embrace Blockchain technology. This finding is supported by studies conducted by Duan et al. (2020), Wamba et al. (2020), and Hu et al. (2021). However, the lack of a notable indirect impact for PU suggests that further investigation is required to understand the relationship between perceived utility, attitudes, and behavioral intentions. This suggests that the influence of perceived usefulness on attitudes is straightforward, but its effect on behavioral intentions is more intricate and contingent on the circumstances (Wamba & Queiroz, 2020; Rocha et al., 2021).

Limitations

While recognizing the excellent contributions, it is crucial to understand the constraints of this study. To begin with, the dependence on self-reported data presents the possibility of response bias since individuals may provide socially desired responses. Furthermore, the applicability of the results is limited to the particular circumstances of the goods logistics sector. The data collection's cross-sectional nature hinders the capacity to establish causal linkages and depict the dynamic character of technology adoption over time. To overcome these constraints, future research should include encompassing a wide range of industrial settings, using longitudinal designs, and corroborating self-reported data with objective metrics (Cheng, 2018).

Recommendations

Based on the findings of the research, we can provide practical suggestions to organizations in the goods logistics sector. To support a quicker adoption process, organizations should engage in extensive training programs, user-friendly interfaces, and proactive communication tactics, recognizing the crucial importance of perceived ease of use. Efforts should focus on demonstrating the practical advantages and use of Blockchain technology to logistics experts, highlighting its favorable influence on operational efficiency and decision-making (Collart & Canales, 2021).

Moreover, cultivating favorable subjective standards within professional networks is essential. Organizations and industry groups may establish platforms for sharing information, promoting collaboration, and hosting conferences where logistics experts can exchange their experiences and views about the deployment of Blockchain technology. The adoption of a community approach has the potential to greatly enhance the ability to overcome opposition and cultivate a culture that is receptive to accepting new technology (Ali et al., 2021; Bischoff & Seuring, 2021).

Future Findings

In order to expand upon the existing study, future studies should investigate the moderating variables that might potentially impact the found connections. An in-depth comprehension may be gained by examining how organizational culture, technology infrastructure, and external regulatory variables influence the adoption landscape. Longitudinal studies enable the examination of the changing patterns of technology adoption over time, capturing the changes in attitudes and intentions that occur in response to continuous technical advancements and market trends (Caldarelli et al., 2020).

Taking into account the possible influence of cultural disparities and disparities in technological readiness across various locations might improve the applicability of results. Subsequent studies may shift their focus from analyzing individuals' intentions to exploring their actual adoption behaviors. This approach would yield a more tangible comprehension of how the incorporation of Blockchain technology impacts operational efficiency, cost-effectiveness, and overall performance outcomes in the freight logistics industry (Cheng et al., 2018; Caldarelli et al., 2020). The transition towards practical evaluations might provide practical and useful information for those involved in the sector and policymakers.

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