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The Influence of Logistics Technology Innovation on the Efficiency of Operations in Small and Medium-Sized Businesses in Thailand

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Abstract

Logistics technology innovation include technology for moving materials and products, such as robotics and automated logistics systems; technology used to transmit information that enables real-time data exchange to optimize material movement; and technology to assist in decision-making as artificial intelligence enhances decision-making. These technologies include the use of digital transformation, automation, and enhanced decision-making tools to increase the efficiency of supply chain operations. This study aimed to examine how environmental factors (legal regulations, market competition, and stakeholder involvement) influence the operational efficiency of small and medium-sized enterprises in Thailand, with logistics technology innovation serving as a mediating factor, and to propose strategic guidelines for improving business performance through innovation. Data were collected from 400 small and medium-sized businesses in the Eastern Special Development Zone which are Chachoengsao, Chonburi, and Rayong provinces. A purposive sampling method was used to select enterprises in logistics-related industries, followed by convenience sampling for survey distribution. The investigation was carried out utilizing structural equation modeling. The findings revealed that environmental variables have a considerable impact on operational efficiency, with logistics technology innovation serving as a mediating variable. The direct effect of environmental factors on innovation technology was strong (β = 0.73), while innovation technology had a significant positive effect on operational efficiency (β = 0.37). Product movement technologies, including robots and automated vehicles, had the greatest influence (β = 0.62), followed by digital data transmission technologies (β = 0.34) and decision support systems (β = 0.06). These results imply that small and medium-sized businesses should emphasize logistics automation, artificial intelligence-driven decision-making, and digital data sharing platforms to increase efficiency. This study offers important insights for corporate executives and politicians in creating a favorable climate.

Keywords: Technology, Logistics, Smes, Operational Efficiency, Environmental Factors

1. Introduction

Presently, the utilization of digital technology in the business operations of small and medium enterprises (SMEs) faces certain challenges within the context of the digital economy's development. Digital technology has been introduced to enhance SMEs' distribution channels, yet it has encountered obstacles in key operational areas, including Selection & Pricing, Content Production, Operational Excellence, Marketing, and Data Analysis for management purposes. It's critical to enhance customer access to items, guarantee the quality of their service, etc. Prior to deciding on the distribution channel's objectives, it is important to analyze the market and ascertain the values that customers expect from its creation [1]. Thus, it becomes imperative to address these challenges in order to leverage information and solve marketing issues, particularly pertaining to transportation, thereby enhancing management efficiency in SMEs.

Employing information technology in logistics management, especially concerning efficient goods transportation, holds the potential to positively impact sales growth. When customers receive reliable and satisfactory delivery services, they are more likely to engage in repeat purchases, leading to increased sales and indicating effective organizational management. Additionally, implementing an efficient transportation management system contributes to cost reduction across various areas, such as transportation costs, warehouse expenses, and opportunity costs. The efficiency of the transportation management system should be evaluated from a variety of angles, including financial

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(a market economy's prerequisite), production (loading and unloading quantities, cargo traffic volumes, and how well they serve the interests of all economic entities) [2]. Furthermore, entrepreneurs who possess a comprehensive understanding of the delivery system and processes can make informed decisions regarding suitable delivery methods for different types of products, thus optimizing cost savings. Ultimately, streamlined loading and prompt delivery of products to their destinations with minimal losses result in lower transportation expenses.

SMEs significantly contribute to employment, innovation, and economic growth even if they are fundamental players in the global economy. But given financial, technical, and organizational limitations, SMEs typically find specific challenges using logistics technology. Even with the benefits, SMEs find some challenges employing logistics technologies. These challenges could be broken down into three groups: financial, technical and organization barriers. The first challenge is financial; small and medium-sized businesses may not be able to afford to use AI and the Internet of Things (IoT) in their work. The high cost of technology, software, and training at the start can be a big problem [3], [4]. Logistics technology may not be used as much as it could be because of limited funds. Second, there are technical issues because Small and medium-sized businesses might not have the trained staff needed to set up and run current logistics systems. There have been issues with putting into practice properly [3], [4]. The complexity of transportation technology could be scary for small businesses, especially those that don't know much about computers. This could make it hard to use and integrate [5]. The third problem has to deal with the organization barriers. Small and medium-sized businesses may face pushback from workers who don't want to use new tools [6], [7]. These problems make it hard to use transportation technology. For small businesses, not having a clear plan for adopting technology could mean bad implementation and few benefits [6], [7].

Hence, one crucial approach to promote SMEs is by strengthening their understanding of logistics services, thereby encouraging the adoption of information technology in marketing. This, in turn, fosters a mechanism that facilitates product innovation and establishes connections between producers and consumers. An integral part of this process involves leveraging information and technology to enhance core logistics activities, thus improving overall business efficiency. So, depending on the type of business, the proper design and implementation of transportation plans play a significant role in a company's ability to compete. Such an operational plan should also be in line with the company strategy. It tries to choose between several options for service levels (frequency and scheduled times for loading and deliveries), fleet ownership (own transportation or use of third parties), and how to combine loads (lots and location of operations) [8]. The accurate, suitable, and up-to-date utilization of technology can significantly contribute to the success of enterprises. In light of these considerations, the researcher proposed a survey-based study to investigate the impact of information technology on business operations and its implications for enhancing efficiency. The findings of this research can provide valuable insights and serve as a guideline for promoting the use of information technology to benefit SMEs' business operators.

Logistics technology offers significant benefits for SMEs, including improved efficiency, cost savings, and enhanced customer service. However, SMEs face several challenges when adopting these technologies, including financial, technical, and organizational barriers. By addressing these barriers through financial support, technical assistance, collaboration, change management, and strategic planning, SMEs can successfully adopt logistics technology and achieve sustainable growth in the digital era. Therefore, this research aims to offer recommendations and contribute to the logistic management system plan for enhancing SMEs' Operational efficiency. By acquiring actionable information on the effective deployment of technology to boost operational efficiency, particularly concerning logistics services for SMEs, it becomes possible to align personnel and technology development strategies with the broader objectives of in Thailand. Furthermore, the gathered information can be utilized for integrated public relations efforts that aim to induce changes in concepts, attitudes, and behaviors related to the adoption of information technology by relevant businesses.

Therefore, this study aims to explore how innovations in logistics technology can enhance the operational efficiency of SMEs in Thailand. The objectives are to investigate innovations in logistics technology, may optimize supply chain operations and efficiency, to examine how environmental factors, such as regulatory laws, market competitiveness, and stakeholder participation, impact SMEs' use of logistics technology and efficiency, to assess how logistics technology innovation influences the relationship between environmental factors and SMEs' operation efficiency, and

to propose guidelines to help small and medium-sized businesses use logistics technology like robots, automated systems, digital data transfer, and decision-support tools to make their operations more efficient and competitive.

2. Literature Review

This literature review examines the environment factors that influence the usage of transportation technology, the most significant new advancements in the sector, and how they impact the operational efficiency of SMEs in Thailand.

2.1. Environmental Factors

The environmental determinants of an organization pertain to the external circumstances and influences that affect its operational activities, performance metrics, and strategic decision-making processes. These factors can include various aspects, such as legal regulations, competitors, and stakeholder considerations [9]. Legal regulation refers to organizations operating within a legal framework that governs their activities. These regulations can pertain to areas such as labor laws, environmental regulations, taxation policies, consumer protection laws, intellectual property rights, and industry-specific regulations. Compliance with these regulations is essential for organizations to avoid legal consequences and maintain ethical practices [10]. Competitors are organizations that operate within a competitive market environment. Competitive forces, as proposed by Michael Porter's Five Forces framework, include the threat of new entrants; the bargaining power of suppliers; the bargaining power of buyers; the threat of substitute products or services; and the intensity of industry rivalry. These forces determine the overall competitiveness of the industry and impact an organization's competitive position and strategy [11]. Stakeholders refer to the external entities or individuals who have an interest or influence over the organization's activities, operations, and outcomes. Stakeholders can include shareholders, employees, customers, suppliers, government agencies, local communities, non-governmental organizations (NGOs), and other entities that have a stake in the organization's success [12].

It is important to note that the specific environmental factors can vary depending on the industry, location, and organizational context. Organizations need to conduct thorough environmental scanning and analysis to identify and respond effectively to the relevant environmental factors influencing their operations. Environmental factors refer to the external conditions that influence an organization's operations, strategic decision-making, and performance. Three important environmental factors were looked at in this study: legal regulations, competitors, and stakeholders. Validated measurement tools taken from previous studies were used to turn these factors into practical factor. Prior studies suggest that compliance with legal requirements affects SMEs' operational efficiency and innovation adoption [13]. Competitors measured market competition intensity; research indicates that firms in competitive industries are more likely to adopt technological innovations for strategic advantage [14], [15]. Stakeholder theory suggests that firms prioritize innovation based on external pressures and stakeholder demands. By incorporating from institutional theory, stakeholder theory, and competitors, this study provides a transparent and structured methodology for assessing environmental factors. The findings contribute to understanding how external pressures drive SMEs to adopt logistics technology.

2.2. Logistics Technology Innovation

Technology plays a significant role in driving logistics innovation by improving efficiency, visibility, and connectivity throughout the supply chain [16]. Technology for moving materials and products. Various technologies are utilized for the movement of materials and products efficiently and effectively throughout the supply chain. Here are some key technologies used for material and product movement in logistics [17]. Conveyor Systems, Automated Guided Vehicles (AGVs), Forklifts and Lift Trucks, Palletizers and Depalletizers, Automated Storage and Retrieval Systems (AS/RS), Robotics and Robotic Arms, Drones, and Warehouse Management Systems (WMS). These technologies enhance speed, accuracy, and productivity in material and product movement within logistics operations [16].

Technology used to transmit information. Various technologies are employed to transmit information efficiently and effectively throughout the supply chain. These technologies enable real-time data sharing, communication, and collaboration among stakeholders. Here are some key logistics technologies used for information transmission: Electronic Data Interchange (EDI), Enterprise Resource Planning (ERP) Systems, Supply Chain Management Systems

(SCM), Transportation Management Systems (TMS), Warehouse Management Systems (WMS), Global Positioning System (GPS), Cloud Computing, Mobile Applications) [17].

Technology to assist in decision making. There are several technologies that assist in decision-making across various domains. These technologies leverage data analytics, artificial intelligence, and automation to provide valuable insights and support decision-making processes. Here are some key technologies used to assist in decision making. These technologies enhance information flow, collaboration, and visibility in logistics operations, leading to improved efficiency and responsiveness [18].

Artificial Intelligence (AI), the Internet of Things (IoT), and digital platforms are becoming increasingly popular among Thailand's SMEs. The need for operational efficiency, competitiveness, and market needs has driven SMEs to use those technologies. However, acceptance varies greatly, with some SMEs aggressively incorporating new technology and others facing considerable barriers. The integration of AI, IoT, and advanced digital platforms is still limited despite continuous attempts to digitize, and only a small percentage of Thai SMEs presently use more advanced technology, with the bulk using simple digital tools [19]. The COVID-19 pandemic has spurred digitalization efforts despite budgetary constraints and challenges, particularly in supply chain management and customer engagement [19].

The transportation industry is increasingly utilizing TMS and online transportation management systems. But people's desire to spend money on these systems depends on things like how easy they are to use, how relevant they are to their workflow, and how much they are thought to help them [20], [21]. For example, people use online freight shipping platforms because they expect them to work well, put in significant effort, and be influenced by their friends and family. However, they are still hesitant to use them because they think they might be unsafe [21]. Thai small and medium-sized businesses are working hard to go digital because of pressure from customers and competitors [19].

SMEs have been forced to look into and adopt new technologies to stay competitive in a market that is changing quickly. The COVID-19 plague has also sped up the use of digital tools as companies try to adjust to new ways of doing things [19]. People perceive Thai SMEs as highly intelligent when they integrate Industry 4.0 technologies such as AI, IoT, and blockchain [3]. It is believed that these technologies will make better use of resources, cut down on working downtimes, and make the supply chain more resilient. However, technical and financial issues prevent widespread adoption of these technologies [3].

While some SMEs have been able to effectively integrate new technologies, others face major issues, including not having enough money or professional know-how or believing the new technology is unsafe. Combining government initiatives, competitive elements, and market demands speeds up the adoption of utilitarian logistic innovation. a continually evolving, intricate process. Process continually evolving. Creating strategic frameworks, supporting cooperation, and solving the particular challenges faced by various kinds of SMEs can help to maximize the possibilities presented by these technologies. SMEs in Thailand may leverage digital technologies, AI, and IOT to incentive innovation, increase business efficiency, and enable long-term growth of their companies. Digital technologies, AI, and the IOT may be used by small and medium-sized Thai companies to inspire fresh ideas, increase output, and accomplish long-term expansion.

2.3. SMEs' Operational Efficiency

The efficiency of a logistics organization can be assessed through various performance indicators, such as on-time delivery, order accuracy, inventory turnover, cost per unit, and customer satisfaction. However, it is important to note that specific efficiency measures may vary depending on the context and goals of the logistics organization [22]. Appropriateness of use refers to the suitability and effectiveness of operational strategies and processes employed within the organization. It involves evaluating whether the chosen operations align with the firm's objectives, industry requirements, and customer needs [22]. Easy Access refers to the efficiency and convenience of accessing and utilizing logistics services or facilities. It involves designing and implementing operational processes that facilitate seamless and quick access to resources, transportation, warehousing, and other logistics activities [23].

Product safety which involves implementing processes and procedures to ensure the safe handling, storage, and transportation of products throughout the supply chain. It includes measures to prevent damage, contamination, or any risks that could compromise the safety and quality of the products being handled. Additionally, product safety operations may encompass compliance with regulations, quality control, and risk management practices. Processing

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time refers to the duration it takes to complete various operational activities and processes within the supply chain. This includes activities such as order processing, picking and packing, transportation planning, inventory management, and other tasks involved in the movement and handling of goods [23].

Reliability refers to the ability to consistently deliver goods and services on time, as promised, and in accordance with customer expectations. It involves building trust and confidence with customers through reliable and predictable operations that minimize delays, errors, and disruptions within the supply chain. Flexibility refers to the ability to adapt and respond effectively to changing conditions, demands, and disruptions within the supply chain. It involves designing and implementing operational strategies and processes that can accommodate variations in customer requirements, market dynamics, and unforeseen events [24]. The benefits of firm efficiency in logistics firms are numerous and can have a significant impact on their overall performance, competitiveness, and profitability. Efficient logistics operations help reduce costs associated with transportation, inventory holding, warehousing, and order processing. By optimizing routes, improving resource allocation, and streamlining processes, logistics firms can minimize expenses and enhance their bottom line [22].

Efficient logistics operations enable faster and more reliable delivery of goods, leading to improved customer satisfaction. Timely and accurate order fulfillment, shorter lead times, and effective communication contribute to customer loyalty and positive brand reputation. Logistical efficiency can serve as a competitive differentiator in the marketplace. Companies that can provide faster and more cost-effective logistics solutions gain a competitive edge over their rivals, attracting customers and securing new business opportunities. Empirical research regularly shows that logistics efficiency has a substantial impact on corporate success. Efficient logistics operations cut expenses for transportation, inventory management, warehousing, and order fulfillment. According to studies, organizations that optimize their supply chain procedures may reduce logistics expenses by 15-30% [25].

Efficient logistics firms are better equipped to respond to market changes, fluctuations in demand, and unforeseen disruptions. They can quickly adjust their operations, reroute shipments, and adapt to dynamic conditions, enhancing their resilience and agility. Efficient logistics operations promote collaboration and information sharing among supply chain partners. By improving coordination and visibility, logistics firms can achieve better synchronization, reduce lead times, and enhance overall supply chain performance. Companies that use efficient logistics as a competitive edge also tend to have a bigger share of the market and keep more customers. There is a strong link between improving logistics, growing the market, and making more money, according to research. Customers are happier and more likely to stay with a business if service is faster and more reliable [26].

When it comes to logistics firms, the benefits of company efficiency show how improving efficiency can lead to good results and help the success of logistics companies. People use the words "Smart Logistics" and "Logistics 4.0" to talk about how Industry 4.0 technologies are used in logistics. With the help of digital technologies [28], Logistics 4.0 is a logistics system that makes it possible to meet the needs of each customer in a way that doesn't raise costs and supports industry growth in an eco-friendly way. Improving a company's performance, competitiveness, and earnings all rely on how well its logistics function. Businesses that improve their mobility can save money, make their customers happy, and gain a competitive advantage in the marketplace. Smart Logistics and Logistics 4.0 leverage cutting-edge digital technology to make things even more efficient by making supply chain activities flow more smoothly.

2.4. Relevant Research

By leveraging advanced technologies, such as IoT, AI, and big data analytics, the logistics firm was able to optimize resource allocation, reduce operational costs, and enhance customer service. The case study provides specific examples and evidence of the benefits derived from technology innovation. The research study conducted by Park and Kim [24] focuses on exploring the role of technology innovation in enhancing logistics service capabilities. The study takes a dynamic capabilities perspective to understand how technology innovation can contribute to the development of effective and sustainable logistics service capabilities. The summary suggests that the researchers adopt a theoretical framework of dynamic capabilities, which emphasizes the ability of organizations to adapt and innovate in response to changing environments. They argue that technology innovation plays a crucial role in enabling logistics firms to develop and enhance their service capabilities in dynamic and competitive markets. The research contributes to the understanding of how logistics firms can leverage technology innovation to develop and sustain competitive advantages in the dynamic business environment. By aligning their innovation strategies with the principles of dynamic

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capabilities, logistics firms can adapt to market changes, enhance their service capabilities, and meet the evolving needs of customers.

The research study conducted by Cui and Ma [28] focuses on examining the impact of technology innovation on the efficiency of the logistics industry. The study employs empirical analysis using two commonly used techniques, Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA), to analyze the relationship between technology innovation and logistics industry efficiency. The summary suggests that the researchers collected data from the logistics industry, likely including variables related to technology adoption, innovation activities, and efficiency measures. They then applied DEA and SFA techniques to assess the efficiency levels of logistics firms and determine the influence of technology innovation on industry efficiency. The findings of the study, although not provided in the summary, likely indicate a positive impact of technology innovation on the efficiency of the logistics industry. The empirical analysis using DEA and SFA allows for a quantitative assessment of the relationship, providing evidence to support the research hypothesis.

3. Methodology

This study uses the structured methodology to look at important factors and data to find out how logistic innovation technologies affect the working efficiency of small businesses.

3.1. Conceptual Framework

AI and the IoT improve the efficiency of the supply chain, which in turn saves money and makes users happy [29, 30]. Systems that are powered by artificial intelligence, for example, make it simpler to anticipate what consumers will desire and to keep track of what is available. However, there is a complicated of connections that exists between the environment and the efficiency with which SMEs carry out their operations. The development of new transportation technologies is among the most significant of them. Technology in the shipping industry has to continue to advance in order to facilitate the seamless operation of small and medium-sized firms. This results in significant cost savings and frees up greater flexibility for enterprises [29]. Innovations in logistics technology act as a go-between for environmental issues and operational performance. SMEs can deal with the problems that come with not knowing what will happen in the environment better by using green transportation methods and digital tools [31]. For example, studies have shown that circular economy practices make operations more efficient [31], which shows that transportation management acts as a go-between for environmental factors and sustainability performance. As a result, new logistics technology is an important link between environmental issues and the working efficiency of small businesses. SMEs can deal with environmental problems, improve their business operations, and grow in a way that lasts by using transportation and digital technologies. This summary shows how important innovation is for making small businesses more efficient and long-lasting. So, the research's conceptual framework is set up as shown in Figure 1, and the following hypotheses are analyzed:

Hypothesis: Logistics technology innovation mediates the relationship between environmental factors and SMEs' operational efficiency.

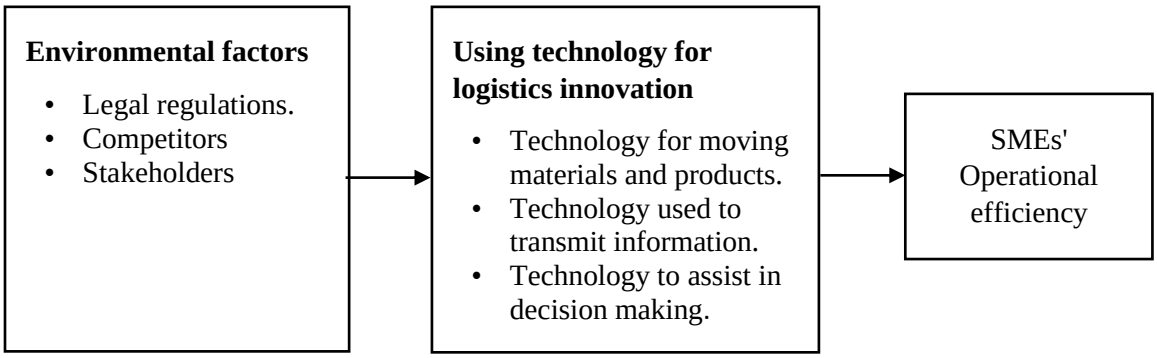

Figure 1. Conceptual Framework

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3.2. Population and Sample Size Determination

The purpose of this study is to investigate how new logistic innovation technologies can help bridge the gap between legal regulation, market competition, and the participation of stakeholders in Thailand's SMEs and their operating efficiency. Small and medium-sized businesses in the Eastern Special Development Zone, which includes the provinces of Chachoengsao, Chonburi, and Rayong, are part of the study group. These businesses deal with transportation. To make sure that all the necessary data was gathered, a selected sample approach was first used to pick logistics-related businesses. To ensure rigorous data collection, a purposive sampling approach was initially employed to select enterprises engaged in logistics-related activities. Subsequently, a convenience sampling strategy was used for survey distribution, ensuring broad representation within the target population.

Determining the optimal sample size for SEM necessitates careful evaluation of model complexity and statistical power. Prior research indicated that SEM requires a minimum sample size of 100 [12]. More robust guidelines, on the other hand, recommend that the sample size be 10 to 12 times the number of estimated parameters. This study's structural model includes three latent variables, environmental factors, logistics technology innovation, and operational efficiency. The six observed variables are three variables for environmental conditions and three variables for logistics technology innovation. The outcome latent variable is SMEs' operational efficiency.

Given the model's complexity and the subsequent [32] suggestions, a conservative approach was chosen, with a minimum sample size of 300 respondents. To boost statistical power and account for any nonresponse errors, 400 responses were gathered, assuring strong empirical validation. The questionnaire survey was conducted from October 2022 to December 2022.

This study uses SEM because it can look at complicated connections between hidden and visible factors at the same time. SEM is better than standard regression analysis because it handles measurement errors better, checks mediation effects better, and lets you use confirmatory factor analysis (CFA) to make sure that constructs are correct [32]. Because the goal of the study is to look at how new logistics technology affects the working performance of small businesses, SEM is a good way to test both direct and indirect effects that regression-based methods can't do well [33].

4. Results

The study results, which show how new transportation technologies have affected the working efficiency of small businesses in Thailand, are shown below.

4.1. Results of General Characteristics and Opinion Level

The results of the analysis of general characteristics of small and medium enterprises (Characteristics of Organization) using descriptive statistics, namely frequency and percentage. These results illustrate the analysis of entrepreneurial characteristics of small and medium enterprises in the Eastern Special Development Zone. Limited companies accounted for the highest percentage, at 34.5 %. For provinces where businesses were located, they would operate in Rayong at the highest percentage (54.8 %). The number of employed individuals was between 1 and 18, most of whom were 43.3 %. The years in operation of the business were between 1 and less than 5 years. 45.8% had baht investments, most over 1 million but under 5 million. 40.8% The type of main products sold most is jewelry and decorations (29.8 %), and the main source of goods is self-made (61.5 %).

The results of the analysis were conducted at the efficient operational opinion levels, using statistical measures such as frequency, mean, and standard deviation. The study looked at organizational factors that affect organizational culture and the use of new logistics technology.

The results showed that most small and medium-sized businesses are very good at using transportation management systems, with an average score of 3.83. To add to that, a look at how organizational factors affect logistics technology innovation shows that most small and medium-sized businesses use modern transportation management systems very well (scoring 4.24). Furthermore, when it comes to organizational factors concerning planning and the adoption of innovative logistics systems, most SMEs have plans to enhance their use of new information technology, scoring the highest mean of 3.87. Overall, the practical level of organizational factors related to logistics technology innovation is rated high, with an average score of 3.89.

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The level of practice in innovation is particularly noteworthy, with a mean score of 4.03. Additionally, organizational environmental factors, such as legal regulations and government policies, are perceived by most businesses to have a positive impact and facilitate the transportation of goods, scoring the highest mean of 4.29. Legal restrictions must be recognized as either facilitators or impediments to the deployment of logistics technologies. Government incentives, tax breaks, and subsidies can assist businesses in adopting new logistics technologies by reducing financial barriers and boosting innovation [34]. Compliance costs, data security regulations, and industry-specific limits may exacerbate the financial and administrative constraints that limit technology adoption [35]. Environmental regulations have been demonstrated in studies to spur innovation, although high compliance costs may discourage smaller businesses from investing in new technologies [36]. As a result, knowing regulatory consequences is critical for developing logistics technology strategies that maximize benefits while minimizing limits. To assist SMEs in navigating the legal landscape, further research should be conducted to assess the balance between regulatory incentives and compliance issues.

The operational level analysis indicates a wide use of technology in the movement of materials and products, with a mean score of 2.82. In terms of information transmission technology, most organizations utilize it at a high level, with a mean score of 3.91. Moreover, the use of technology to aid decision-making is rated high, with a mean score of 4.04. Organizations also demonstrate the ability to select appropriate transportation systems for their products, with the highest mean score of 4.30. The overall average score for the operational level analysis of technology utilization for innovation is 3.59, indicating a high level of practical application. Notably, technology-assisted decision-making demonstrates the highest level of practice, scoring 4.04. Additionally, operational efficiency in the transportation process, measured through the use of technology, is rated at the highest level of 4.34.

Regarding opinions on organizational environmental factors, findings reveal that most organizations possess an efficient transportation management system and are willing to invest in systems comparable to their competitors, with a mean score of 4.09. Moreover, concerning stakeholder-related factors, most businesses perceive their freight management system as highly accepted, scoring the highest mean of 4.35. Overall, the organizational environmental factor receives a mean score of 4.24, signifying the highest level of opinion. These results highlight the perceptions of businesses regarding environmental factors that influence the transportation management system, indicating a high level of agreement.

Our findings show that SMEs in the Eastern Special Development Zone use a high degree of logistics technology, notably transportation management systems (mean score: 3.83) and decision-support technologies (mean score: 4.04). This tendency is in line with global trends, in which SMEs are fast integrating digital technology to raise operational effectiveness. However, as compared to bigger businesses, SMEs tend to lag in the adoption of new digital technology. A thorough literature assessment spanning a decade of contributions on technology adoption in SMEs reveals that, despite the potential benefits, SMEs face considerable barriers to adopting modern technologies when compared to bigger enterprises. This gap is sometimes linked to budget constraints and inadequate ICT infrastructure inside SMEs [37].

4.2. Results of Hypothesis Testing

To test the logistics technology innovation mediates the relationship between environmental factors and SMEs' operational efficiency. The research employed the computer programs SPSS for Windows and AMOS for Window (Analysis of Moment Structures) to examine the causal relationships that influence the purchase intentions of online tourists and assess the consistency between the models proposed by the researcher and the empirical data. This analysis involved evaluating the direct, indirect, and total influence of the variables on the purchase intention of online tourists, using the maximum likelihood estimates (Maximum Likelihood Estimates = ML). The results of this hypothesis analysis are presented in the following order to ensure consistency between the assumptions made and the empirical data collected.

4.2.1. The Full Causal Relationship Path Analysis Model

To facilitate understanding of the data analysis results in this research, the researcher created a full causal path analysis model (over-identified model) as illustrated in figure 2. The researcher has also defined the abbreviations used in the analysis to ensure clarity in the presentation of the results in table 1.

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Table 1. The abbreviation of variables.

Abbreviation	Meaning
env_law	Legal regulations
env_competion	Competitor
env_stakeholder	Stakeholder
IT_moveproduct	Technology used to move materials and products
IT_transferdata	Technology used to transmit data
IT_dss	Technology for decision making
SMEs' Operational efficiency	Performance of operations as measured by using technology
e	error margin

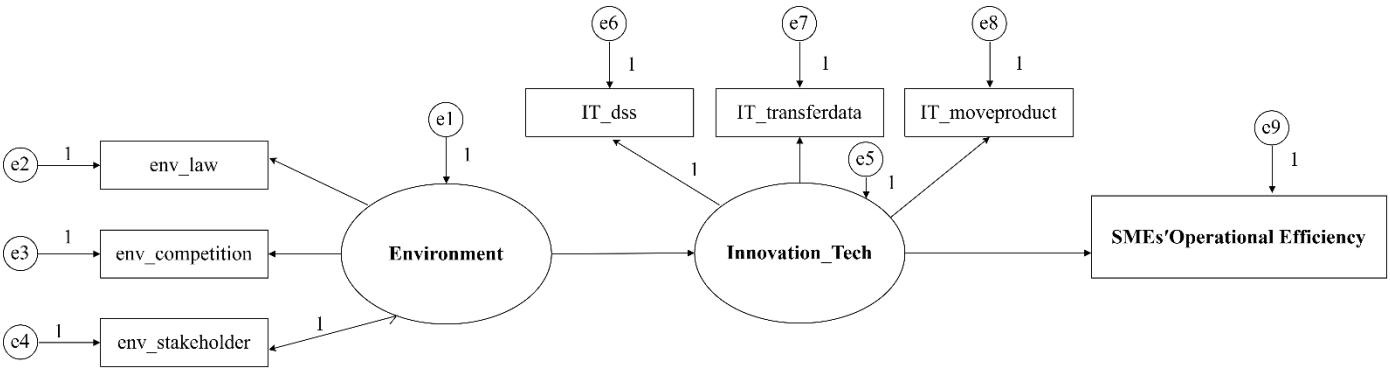

Figure 2. The model format of the path analysis of the variables under study

4.2.2. The Intercorrelation Between Variables

The Pearson Correlation Coefficient is a tool for determining the correlation between variables in research studies. It can help determine if variables are independent or not, and can also be used to test the relationship between independent and dependent variables. It is important to ensure that variables used in the study do not have too much covariance, which can cause issues with multicollinearity. To prevent analytical errors, it is recommended that the correlation between variables be no greater than 0.75. The coefficient can also be used to calculate the total bivariate correlation of model variables, as show in table 2.

Table 2. The values of the correlation coefficient between the variables.

	SMEs's Operational Efficiency	Environment (Env)			Information Technology (IT)		
		Law	Competition	Stakeholder	Move product	Transferdata	DSS
SMEs's Operational Efficiency	0.119						
Env_law	0.181	-0.001**					
Env_competition	-0.096**	-0.134**	-0.100**				
Env_stakeholder	0.122	0.003*	-0.022**	-0.001**			
IT_moveproduct	-0.751**	-1.566**	-0.871**	-1.162**	0.044*		
IT_transferdata	-0.147**	0.042*	0.425	-0.275**	0.673	0.000*	
IT_DSS	0.014*	-0.061**	0.168	0.114	0.054	0.054	0.045*

*Note: There are important statistical implications * p < 0.05, ** p < 0.01*

Upon considering the results of the correlation analysis conducted on all variables, it was observed that the majority of correlation coefficients were positive, indicating 28 pairs of variables exhibiting relationships in the same direction. Conversely, there were 13 pairs of variables showing a negative correlation, representing relationships in the opposite direction. Moreover, 13 pairs of variables demonstrated significant correlation at the .01 level, while 6 pairs exhibited significant correlation at the .05 level. Importantly, all pairs of variables-maintained correlation values below the

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specified threshold of 0.75. Based on these findings, it can be concluded that the utilized variables were appropriate, as none of them displayed correlations exceeding the high threshold of 0.75.

The correlation study found a number of important links that have a big effect on how well small and medium-sized businesses run. The technology used to move goods and materials has a strong negative link with operational performance (-0.751, $p < 0.01$). Logistics technology that doesn't work right can have a big impact on how well a small business does, as this study shows. The technology used to send data (IT_transferdata) also has a negative association (-0.147, $p < 0.01$), which means that problems with data transfer technologies could make operations less efficient. On the other hand, environmental law has a positive relationship (0.181), which means that following the rules may lead to better operational performance. This is most likely because it helps keep operations organized and moving easily. Environmental competition, on the other hand, has a negative association (-0.096, $p < 0.01$), which means that strong competition may make it harder for small businesses to do their jobs, which makes them less efficient. These results show how important transportation and digital technology are for solving business problems. This also shows how important it is for small and medium-sized businesses to plan ahead and invest in their IT systems so that it works better and lasts longer.

4.2.3. The Estimated Parameters and Coefficients of The Model

The statistical value is utilized to demonstrate the correlation between variables and estimate the results of the model variables or different coefficient estimates. This includes the standardized regression weight, standard error, critical ratio or t-value, and p-value. These results are presented in table 3.

Table 3. Display the results of the estimated correlation coefficients between variables

Path			Estimate	S.E. (Standard Error)	C.R. (Critical Ratio)	P-value	Sig
Innovation_Tech	←	Environment	0.829	0.053	15.721	***	yes
IT_moveproduct	←	Innovation_Tech	0.591	0.096	6.159	***	yes
env_competition	←	Environment	0.801	0.039	20.769	***	yes
env_law	←	Environment	0.974	0.040	24.066	***	yes
IT_transferdata	←	Innovation_Tech	0.896	0.050	18.076	***	yes
smeperformance	←	Innovation_Tech	0.758	0.041	18.441	***	yes
Innovation_Tech	←	Environment	0.829	0.053	15.721	***	yes
IT_moveproduct	←	Innovation_Tech	0.591	0.096	6.159	***	yes
env_competition	←	Environment	0.801	0.039	20.769	***	yes
env_law	←	Environment	0.974	0.040	24.066	***	yes

*Note: There are important statistical implications *p<0.05, ** p<0.01,***p<0.001*

A path model was constructed in figure 2 to analyze statistical values and create a fully identified model of relationships (an overidentified model). This model can connect to dependent variables that are either internal variables or latent variables in every structural equation, and it demonstrates the statistical relationship between the variables using standard regression coefficients (Standardized Regression Weights), t-Value (critical ratio: C.R.), p-Value, and Standard Error (S.E.). Figure 3 displays the analysis results.

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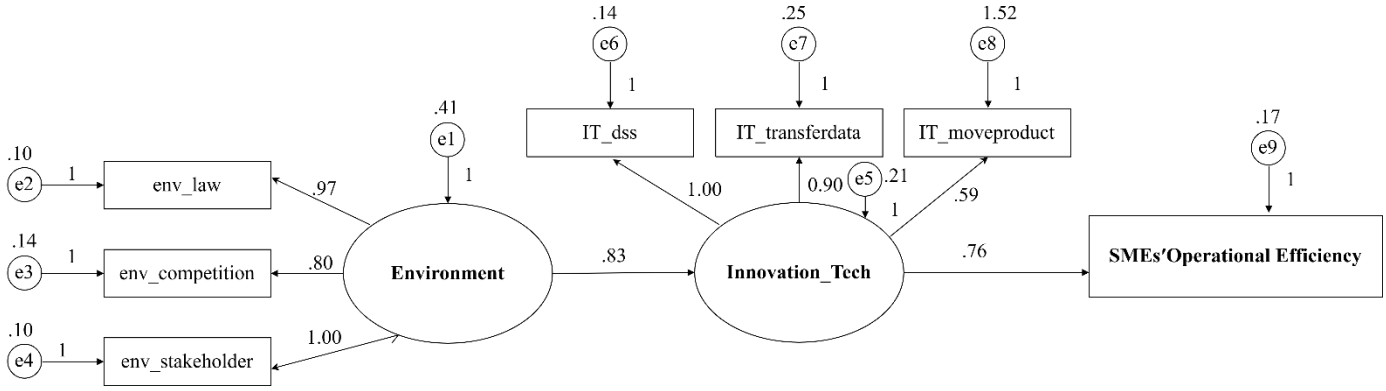

Figure 3. Display the estimated parameter values of the model or the estimates of various coefficients

According to the measurement model's results, the data was valid and dependable, had a high overall model fitness, and could be applied to route analysis. The path analysis values are GFI = 0.869, NFI = 0.890, RMSEA = 0.188 with a PCLOSE value of 0.000, and CMIN/df = 15.088. The model's overall poor fit is demonstrated by CFI =.896 and TLI = 0.832, as the RMSEA is too high and the CMIN/df should have a suggested threshold between <3 (good) and <5 (acceptable). Consequently, the model modification findings shown in figure 4 indicate that the model has to be improved to guarantee completeness and reliability, according to the first assessments of the model's fit.

4.2.4. Model Adjustment

It was found that all path coefficients were statistically significant after a full study of causal route coefficients. This means that the relationships between factors were good. However, the first evaluation of model fit showed that changes needed to be made to make the model fuller and more reliable. The model was made better by looking at path links again, changing constraints, and making sure that theory predictions and real-world data were more in line with each other. The changes were check the scaled regression values again to make sure that all paths are important, making the model limits better so that the structure equation can be identified better, getting better at the connections between variables without getting rid of any constructs, making sure that all paths are statistically significant, and improving fit scores by making path loadings and links between latent variables better.

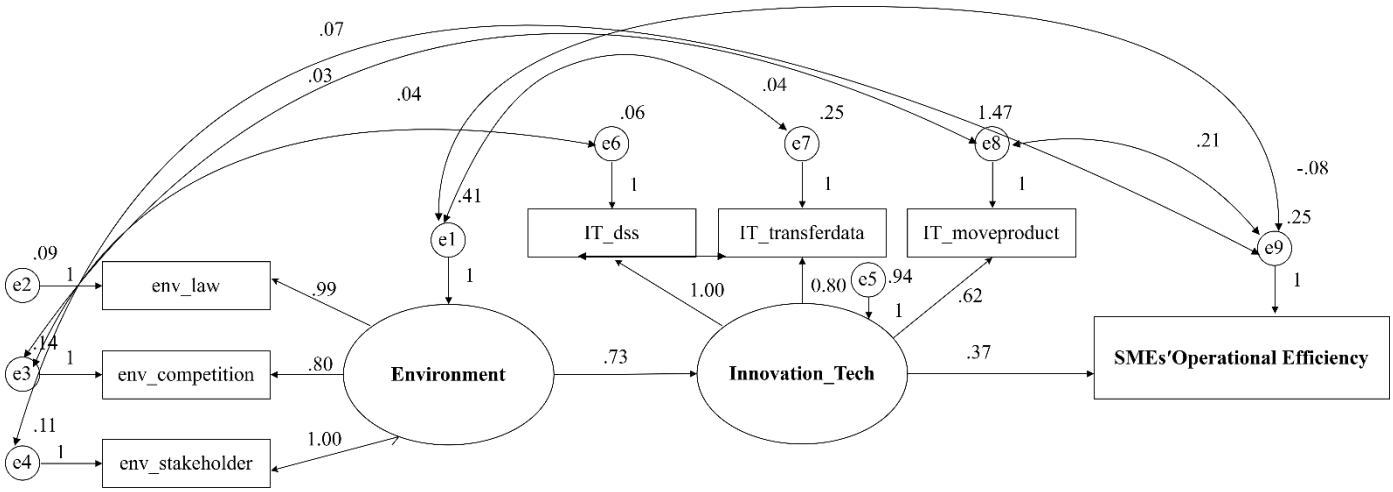

Figure 4. Displays the results of model parameter estimation or results of estimation of various coefficients after model adjustment

The modified model's good overall fit indicates that the data is reliable and warrants further investigation. Model fit indices that meet or exceed specified benchmarks indicate a good fit between the proposed model and the observed data. The CMIN/df value of 1.305, significantly within the permitted range (<3), indicates that the theoretical model

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and real data have minimal difference. Furthermore, the RMSEA of 0.028 and PCLOSE of 0.756 demonstrate a strong match, indicating a minor approximation error in the model. The GFI (0.994), NFI (0.995), CFI (0.999), and TLI (0.996) all have values more than the required threshold of 0.90, with the majority approaching 1.0, indicating a nearly perfect match, confirming the model's robustness. All of these results show that the model makes sense and correctly shows how the factors are related to each other. This means that it can be used for more route analysis and hypothesis testing.

The findings of the structural equation analysis are presented in figure 4, which displays the standard regression coefficients of variables using symbols to indicate their level of statistical significance. The data analysis revealed that all pairs of variable relationships had a statistical significance of less than 0.05.

4.2.5. Analysis of the Influence of Interstitial Variables (Mediating Effect)

The correlation between the modeled variables was strong, indicating that the relationship between them was optimal. Therefore, the modified correlation model will be used to calculate direct, indirect, and total effects, including the indirect effect of mediator variables. A mediator variable is a third variable that comes between the independent variable (x) and the dependent variable (y) and acts as a bridge between them. Although x and y may have a weak correlation, it was found that they were highly correlated when analyzed through the mediator variable, suggesting that there may be a factor that connects x and y. To analyze intermediate influences using the AMOS program, two steps were taken: Step 1 involved finding the direct influence between the independent and dependent variables. Step 2 involved controlling the mediator by incorporating it into the model, and then testing the significance of the indirect influence using Bootstrapping. If the direct influence becomes insignificant, it is a complete mediator, whereas if the direct influence decreases but remains significant, it is a partial mediator.

The hypothesis shows how environmental factors affect the operational efficiency of small and medium-sized businesses (SMEs), including the development of new logistics technology. This is done with the standard regression coefficient. Table 4 shows that environmental influences ($\beta = 0.000$) do not directly affect the operational efficiency of SMEs. But they show a notable indirect impact ($\beta = 0.255$) through innovations in logistics technology, therefore verifying that technology acts as a partial mediator in this connection.

On the other hand, SMEs' operational efficiency ($\beta = 0.412$) is strongly directly influenced by logistics technology innovation; yet there is no indirect effect ($\beta = 0.000$). The evidence suggests that rather than direct environmental factors directly influencing performance, technology developments mostly drive the efficiency increases in SMEs. These results imply that although environmental elements by themselves might not directly increase the operational efficiency of SMEs, they are critical in encouraging the acceptance of logistics technology innovation, which finally increases efficiency. Moreover, the p-value from table 3 (Regression Weights) below 0.001 at the 0.05 significance level lends weight to the relevance of these correlations.

Table 4. Display the results of the analysis on the direct influence, indirect influence, and the total impact between variables

Dependent variable	Effects	Independent variable	
		Environment	Innovation Technology
SMEs' Operational efficiency	Direct	0.000	0.412
	Indirect	0.255	0.000
	Total	0.255	0.412

In summary, the findings offer convincing proof in favor of the theory that innovation in logistics technology moderates the link between environmental elements and operational efficiency of SMEs. Although environmental elements have no direct influence, their use for innovation greatly helps to increase operational efficiency. This emphasizes the need of creating an atmosphere that supports technological developments as SMEs performance is much improved by logistics technology.

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5. Conclusion and Discussion

This research shows that environmental factors have a big impact on how small and medium-sized businesses (SMEs) adopt transportation technology and make their operations more efficient. Our results show that environmental factors don't have a direct effect on working efficiency (β = 0.000); however, they do have a big effect indirectly (β = 0.255) through new transport technology. Adopting transportation technology also makes operations much more efficient (β = 0.412), and it plays a key role in mediating this relationship. The results show how important it is for small and medium-sized businesses to be able to use new technologies in a legal and business context that is friendly to them.

The environmental factors influencing logistics technology adoption were ranked based on standardized regression coefficients from our analysis to guidance for SMEs and policymakers. Legal regulations and government policies (β = 0.974) emerged as the most influential factors, shaping technology adoption through both enabling incentives (e.g., tax breaks, subsidies) and compliance constraints (e.g., data security laws, industry-specific mandates). Small and medium-sized enterprises must manage these rules carefully to maximize advantages while minimizing compliance expenses. Competitive pressure (β = 0.801) drives organizations to embrace modern logistics technology like transportation management systems and automation to stay efficient and competitive. Stakeholder influence (β = 0.758) emphasizes the significance of collaborating with suppliers, consumers, and technology providers to drive logistics innovation in digital supply chains.

Changes in technology have a big effect on how well processes work. AI-powered decision-support and analytics systems boost business performance (β = 0.591) by making it easier to handle costs, supplies, and transportation. A moderate effect is caused by data transfer technology (β = 0.425), which includes digital contact and real-time tracking tools. This is especially true in e-commerce and international supply chains, where the flow of information is very important. The technology that moves things around (β = 0.044), such as robotics in operations and transportation, has the least impact. Because it's more expensive and harder to set up, this shows that small and medium-sized businesses value information management and decision-support technology more than real machinery.

These results give small and medium-sized businesses a way to prioritize adopting new technologies based on their long-term goals and market trends. Policymakers could make small and medium-sized businesses (SMEs) more competitive and efficient in their logistics by giving them specific rewards that encourage both technological innovation and following the rules.

Several external factors were looked at in our study to see how they affected the use of transportation technology by SMEs. Based on our research, the most important factors were found to be legal rules and government policies. These can both help people by offering benefits like tax breaks and grants and holding them back by making it expensive to follow the rules. This two-part role of regulatory structures in shaping technological innovation in small businesses is in line with what other study has found [38]. After that, competition became a major factor that pushed small businesses to use advanced shipping technologies to stay ahead in the market. This was supported by research that showed how market trends affect the adoption of new technologies [39]. Lastly, stakeholder impact, which includes working together with suppliers, users, and technology providers, is also a key part of making technology adoption easier. This is in line with research that shows how important it is for SMEs to involve stakeholders in their digital transformation [40]. By noticing and ranking these factors, small and medium-sized businesses can come up with better ways to integrate logistics technologies, which will improve their business's efficiency and place in the market.

Although this study shows how outside factors affect small businesses' usage of shipping technology, it has some flaws that should be emphasized so that further studies can be enhanced. First, sample selection bias exists as the research only covers Eastern Special Development Zone small businesses. This suggests that small businesses in many other fields or specialties may not find the outcomes significant. More varied industries and areas should be the main emphasis of further studies. Second, it is challenging to get accurate findings since respondent's self-report their poll answers; so, reaction bias or different opinions on the degree of technology usage might follow. Even better would be if the research included real success metrics, such as cost savings or increased production. Third, bear in mind that this research solely examines how shipping technology influences things. Things that may influence the outcome, such as the size of the company, the complexity of the supply chain, or the ease of access to digital infrastructure, are not considered. It may assist the model be utilized in future projects by including new ideas and conducting ongoing tests

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to evaluate how the outcomes develop over time. This study highlights these difficulties, allowing for future research to provide a more complete picture of how small enterprises employ contemporary technology.

6. Recommendation and Future Research

Because of the study, it was found that regulation needs, competition pressures, and shareholder input are all big reasons why small businesses might or might not adopt transportation technology. The results show that external factors don't have as much of an effect directly, even if they do have an effect indirectly by encouraging the use of new technology that makes operations more efficient. There are a lot of specific suggestions that can help with dealing with these problems.

The first thing lawmakers could do is push for rules that help small companies. Digital tools could make it easier to follow the rules, legal help could be paid for, and regulatory sandboxes could be set up so small businesses can try out new ways of doing things before they must fully follow the rules. Also, financial benefits like tax breaks, low-interest loans, and government-backed technology adoption grants need to be taken care of, especially for small businesses that operate in areas with a lot of rules. Infrastructure improvements like funding for cloud-based transportation software, faster internet in industrial zones, and the building of regional technology hubs will help bring down costs and make technology easier to access.

Training and capacity-building projects can be made stronger with partnerships between businesses and universities, licensing programs, and guidance networks. This will help small and medium-sized businesses use transport technology more effectively. Small and medium-sized companies, large businesses, and technology providers should all work together to promote sharing of information, best practices, and joint investments in transportation technology solutions. The research and development (R&D) money should also be used to find transportation solutions that are good for small businesses and don't cost a lot of money. When businesses and colleges work together on test projects, they come up with new ideas for AI-powered operations and automation. Long-term acceptance relies on a creative culture. To help encourage this kind of acceptance, the government can offer reward programs, new benefits, and flexible business models that allow for constant digital change.

Lastly, future research should investigate a few key areas that build on these results. First, it's important to keep looking into how small businesses' transportation technology changes their long-term efficiency, effectiveness, and ability to make money. Second, it's important to compare regional studies to find out how variations in market conditions, laws, and access to infrastructure affect how people use technology in various parts of the world. Third, we need to conduct studies in specific fields to understand how the use of transportation technology evolves in locations with varying regulatory frameworks. For instance, we should examine the food safety industry, the medicine industry, and the car supply chain. Fourth, research that looks at influencing factors, such as the size of the company, the complexity of the supply chain, and the availability of digital infrastructure, will help us understand when environmental factors really work to encourage people to adopt new technologies. They will help us learn more about how small and medium-sized businesses can best use transportation technology if they are filled in. It will also help lawmakers figure out what they need to do next to support long-term economic growth that benefits everyone

7. Declarations

7.1. Author Contributions

Conceptualization: S.I., S.W., K.R. and E.S.; Methodology: S.W.; Software: S.I.; Validation: S.I., S.W., K.R. and E.S.; Formal Analysis: S.I., S.W., and K.R.; Investigation: S.W.; Resources: S.W.; Data Curation: S.W.; Writing Original Draft Preparation: S.I., S.W., and E.S.; Writing Review and Editing: S.I., S.W., and K.R.; Visualization: S.W.; All authors have read and agreed to the published version of the manuscript.

7.2. Data Availability Statement

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

7.3. Funding

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7.4. Institutional Review Board Statement

Not applicable.

7.5. Informed Consent Statement

Not applicable.

7.6. Declaration of Competing Interest

All authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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