The factors influencing the technological innovation activities of enterprises utilizing port services in Binh Dinh Province

ABSTRACT

This study applies the Unified Theory of Acceptance and Use of Technology (UTAUT) to identify key factors influencing technological innovation activities of enterprises using port services in Binh Dinh Province. A mixed-methods approach was employed, combining a literature review, in-depth interviews, and focus group discussions to develop and validate the research model. The results reveal six significant factors: Performance Expectancy, Effort Expectancy, Social Influence, Facilitating Conditions, Innovation Culture, and Perceived Cost. In addition, control variables such as business type, size, service utilization, and geographical location also affect innovation activities. The findings provide empirical evidence and managerial implications to foster technological innovation among enterprises in the port service sector of Binh Dinh Province

Keywords: Technological innovation, Enterprises, Port services.

Các yếu tố ảnh hưởng đến hoạt động đổi mới công nghệ của các doanh nghiệp sử dụng dịch vụ cảng biển trên địa bàn tỉnh Bình Định

TÓM TẮT

Dựa trên nền tảng Lý thuyết thống nhất về chấp nhận và sử dụng công nghệ UTAUT, nghiên cứu này thực hiện nhằm mục tiêu xác định các yếu tố và xây dựng mô hình nghiên cứu các yếu tố ảnh hưởng đến hoạt động đổi mới công nghệ của các doanh nghiệp sử dụng dịch vụ cảng biển trên địa bàn tỉnh Bình Định. Nghiên cứu sử dụng phương pháp tổng quan nghiên cứu kết hợp với phương pháp nghiên cứu định tính và định lượng thông qua phỏng vấn sâu và thảo luận nhóm trọng điểm để xác định các yếu tố ảnh hưởng đến hoạt động đổi mới công nghệ của các doanh nghiệp sử dụng dịch vụ cảng biển trên địa bàn tỉnh Bình Định từ đó kiểm định mô hình nghiên cứu. Kết quả nghiên cứu đề xuất có 6 yếu tố ảnh hưởng đến hoạt động đổi mới công nghệ của các doanh nghiệp sử dụng dịch vụ cảng biển trên địa bàn tỉnh Bình Định bao gồm Kỳ vọng về hiệu suất, Kỳ vọng nỗ lực, Ảnh hưởng xã hội, Điều kiện thuận lợi, Văn hóa đổi mới và Chi phí cảm nhận. Ngoài ra hoạt động đổi mới công nghệ bị tác động bởi các biến kiểm soát là loại hình doanh nghiệp, quy mô, dịch vụ sử dung và địa bàn. Kết quả nghiên cứu giúp có cái nhìn khoa học hơn để đưa ra các kết luận và hàm ý quản trị nhằm thúc đẩy hoạt động đổi mới công nghệ của các doanh nghiệp sử dụng dịch vụ cảng biển trên địa bàn tỉnh Bình Định

Từ khóa: *Đổi mới công nghệ, Doanh nghiệp, Dịch vụ cảng biển*

1. INTRODUCTION

The world is undergoing a significant transformation driven by the Fourth Industrial Revolution. Today, the participants in the global economy are evolving and growing stronger. Alongside this growth, the competitive pressures on individuals and organizations are increasing, requiring them to continuously enhance their capabilities and competitiveness. With the advancements of the Fourth Industrial Revolution, the role and position of the logistics industry in economic development have been affirmed. Logistics and supply chain management are terms frequently mentioned as central to the flow of goods, information, and finance. Therefore, alongside promoting economic development, countries are focusing on modernizing logistics information systems to meet contemporary requirements for goods distribution, recognizing that this investment is crucial.

In Vietnam, the logistics sector plays a vital role in supporting economic development and acts as a lever for economic growth. However, according to leading global economic experts, "logistics costs are a criterion considered before making investment decisions, and countries with lower logistics costs have a higher competitive advantage." In Vietnam, logistics costs remain high, accounting for approximately 16-17% of total costs, which is relatively elevated compared to regional and continental averages. Aside from costs, the logistics infrastructure does not adequately meet the needs of economic development. Thus, the logistics industry is a focal area of interest for the Party, Government, and local authorities, with a central task identified as modernizing the logistics sector to boost production, business, and goods circulation. As reported by the government's electronic portal, addressing the "bottleneck" in logistics is essential for achieving new objectives, and this requires innovative solutions.

According to Commercial Law "Logistics services encompass a comprehensive range of 17 services, with the main categories including transportation, warehousing, loading and unloading, and freight forwarding". These core services facilitate the smooth and efficient movement of goods. Within logistics, transportation is fundamental, which includes road, rail, air, and water transport. Among these, water transport has significant advantages, prompting localities and nations with extensive coastlines to focus on developing their maritime economies. Efficient port services and the development of port facilities are crucial foundational steps for advancing other industries and the overall economy. Vietnam's coastline

stretches along its length and features numerous ports, particularly deep-sea ports, making the maritime economy and port services sectors that localities are keen to invest in and exploit.

In terms of the scope of the study, the research was registered for implementation from May 2025 to May 2026. However, due to the merger policy effective from July 1, 2025, Binh Dinh province will merge with the former Gia Lai province, adopting the new name of Gia Lai. Therefore, the study will analyze the new area of Gia Lai province. Nonetheless, the port system of Gia Lai province is still located in the former Binh Dinh province, and many businesses utilizing port services are concentrated in the former Binh Dinh. This is the reason why the study will focus on the newly merged area, now known as Gia Lai province.

According to Gia Lai Online Newspaper, Binh Dinh Province, located in the southern part of the Central Key Economic Region, boasts several ports, including the deep-water Quy Nhon Port. "One of the five pillars of economic development identified by Gia Lai Province is port logistics services". The province has four major ports: Quy Nhon Port, Tan Cang Quy Nhon, Tan Cang Central, and Thi Nai Port. In the development plan leading up to 2025, the port system will continue to expand, increasing to nearly 90 hectares—three times its current size—to fulfill its role as a gateway port for the Central Key Economic Region. The port system in Gia Lai is categorized as part of Group 3, featuring multipurpose container terminals, bulk cargo, liquid/gas terminals, and passenger terminals, serving the socio-economic development of the locality and the Central Highlands region. The ports accommodate container ships and bulk carriers with capacities up to 50,000 tons (including the ability to receive passenger ships) and liquid/gas vessels up to 10,000 tons or more, provided they meet the necessary conditions.

Ports in Gia Lai are being increasingly modernized to promote local economic development. However, in alignment with the Fourth Industrial Revolution and the "Resolution No. 57-NQ/TW dated December 22, 2024, of the Politburo on breakthroughs in scientific, technological development, innovation, and national digital transformation," as well as the "Action Program No. 32-CTr/TU dated February 17, 2025, of the Provincial Party Committee implementing Resolution No. 57-NQ/TW", the push for innovation is more crucial than ever. In addition to technological innovations in port service provision, effective innovation also requires partners, namely customers and enterprises utilizing port services, to undergo transformation. Currently, many enterprises using port services in Gia Lai are small and medium-sized, often operating in fragmented and small-scale businesses, resulting in limited investment in both hard and soft technology. This lack of synchronization hampers the effective utilization of services.

According to Nhat Minh, The fundamental reasons include reluctance to change among enterprises, an inability to assess the effectiveness of innovation projects, and particularly limited financial resources, with staff capabilities not adapting to innovation. Furthermore, innovation has not yet been established as a core cultural value within these enterprises.

Studies on technological innovation in businesses have been conducted by Vieites and Calvo, Gnyawali and Park, Uzkurt et al, Thong, identifying various factors influencing technological innovation, including organizational resources, technology, finance, information, collaborative linkages, human resources, cooperative partnerships, and information management.[1,2,3] Additionally, Azarmi identified three key factors affecting innovation activities: support, knowledge, and technology[4]. Rangus and Slavec demonstrated that decentralization positively impacts business innovation[5].

In the maritime sector, research has primarily focused on the digital transformation of ports and port businesses, as highlighted by Yang et al, Sun Xuyuan, P.T.Yen and N.T.H.Giang, and L.S.Tung, who noted pressures from regulatory agencies and standardization demands.[6,7,8,9] N.M.Cuong and P.V.Hung further emphasized challenges such as a lack of digital skills, resistance to change from employees, data security concerns, and difficulties in integrating existing traditional systems.[10]

These studies indicate a gap in specific research regarding the factors influencing technological innovation in seaport operations, particularly concerning software technologies for businesses that supply and utilize port services.

The study by N.T.A.Van and N.K.Hieu,[11] Innovation has become a guiding principle for enterprise actions, with some asserting that "innovation is life; without innovation, there is death". Thus, today, innovation is an inevitable trend for enterprises. However, research on the factors influencing technological innovation activities has largely been limited to descriptive

statistics and expert opinions. Some studies have evaluated factors affecting the intention to innovate technology among small and medium enterprises in Ho Chi Minh City as in the study by Duong Thi Anh Tuyet,[12] but participants these studies focused solely on the food processing industry and did not explore broader technological innovation factors.

Consequently, the author has chosen the topic "Developing a Model of Factors Influencing the Technological Innovation Activities of Enterprises Utilizing Port Services in Binh Dinh Province," building upon the foundational theory of the Unified Theory of Acceptance and Use of Technology (UTAUT) Venkatesh et al and prior research.[13] This study will also synthesize insights from experts and managers to construct and propose a research model, serving as a basis for more in-depth quantitative studies.

2. CONTENT

2.1. Theoretical Framework

2.1.1. Concepts

Technology

In the context of technology management by N.D.Dau and N.X.Tai,[14] there are four key aspects to consider in defining technology: technology as a transformation machine, technology as a tool, technology as knowledge, and "technology as embodied in its various forms".

Based on these aspects, the definition of technology provided by the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) states: "Technology is systematic knowledge about processes and techniques used to transform materials and information. It includes knowledge, skills, equipment, methods, and systems used in the production of goods and the provision of services".

According to the Law on Science and Technology "technological innovation is the activity of replacing part or all of the current technology with another part or entirely different technology in order to enhance productivity, quality, and competitiveness of products" emphasizes the importance of adapting and upgrading technology to stay competitive in the market. This definition highlights innovation as a fundamental process for improving operational efficiency and product quality.

Technological Innovation

Technological innovation is a trend that nearly all individuals and businesses are pursuing in their actions, as it serves as a competitive tool for enterprises. There are various perspectives on technological innovation. It is the proactive replacement of significant (core) or all existing technology with a more advanced and efficient technology. Technological innovation may aim to optimize production parameters such as productivity, quality, and efficiency (process innovation) or create new products and services for the market (product innovation). It can involve the introduction or application of entirely new technologies not yet available in the market or the first use of existing technologies in a completely new context.

According to the OECD, technological innovation includes new products, processes and significant technological changes in products and processes. An innovation when it is introduced to the market. The perspective states: "Technological innovation is the activity of replacing part or all of the existing technology with another part or all of a different technology to enhance productivity, quality, and competitiveness of products".

Port Services

In the definition of logistics, ports play a crucial role as a bridge in the flow of goods, occupying an important position in the supply chain and directly influencing the outcomes and efficiency of the transportation process. According to the Circular of the Ministry of Transport, Port services encompass "a variety of activities that support the transportation of goods and vessels entering and leaving the port. These services can be categorized in various ways but generally include services related to vessels, cargo, and other supporting services such as towing, warehousing, and loading/unloading."

Port services are defined as "services provided by service enterprises or shipping companies or representatives of shipping companies that charge fees to customers for facilitating the transportation of goods and passengers through ports." Furthermore, "services at ports are understood as those provided by service enterprises or shipping companies or their representatives that charge fees to customers for facilitating the transportation of goods and passengers through ports".

Enterprises Utilizing Port Services

Enterprises utilizing port services are viewed as significant customers influencing the investment decisions of service providers. Today, alongside investments in innovative activities and digital transformation toward building smart and green ports, there is a need for collaboration in innovation from customers, namely the enterprises utilizing port services. Currently, there are numerous hardware and software technologies that must be compatible and synchronized between providers and users, particularly software technologies aimed at optimizing operations, including warehouse management, cargo handling, and tracking journeys and customs procedures. These technologies include: "Terminal Operating Systems (TOS), Internet of Things (IoT), Big Data, Artificial Intelligence (AI), automation, blockchain, and intelligent monitoring systems."

2.1.2. Theoretical Framework

Technology Acceptance Model (TAM)

The Technology Acceptance Model (TAM) is one of the most widely used research frameworks for predicting individual behavior regarding the acceptance and use of technology. Developed from the Theory of Reasoned Action (TRA) by David,[15] TAM specifically focuses on the use of information technology. Recent studies have extensively employed TAM to explore how individuals accept various technology ideas.[5] Research utilizing this model has measured the intention to use a system among the same group of individuals over different time periods.

There is a strong relationship between perceived usefulness and actual usage behavior. While perceived ease of use has a smaller but significant impact on behavioral intention, the primary findings indicate that both perceived usefulness and perceived ease of use directly influence the intention to use technology. Therefore, the model has eliminated the attitude component from the original model structure.

Innovation Diffusion Theory (IDT)

To explain innovation and the recognition of its value and benefits, Everett Rogers introduced the Innovation Diffusion Theory (IDT) by Rogers in 1969 and further developed it in 2003.[16] In the customer decision-making process, acceptance signifies that customers are ready to adopt innovations as trends. Conversely, a lack of acceptance indicates a refusal to embrace new innovations.

The concept of innovation diffusion is defined as "the process by which an innovation is communicated among members through fixed communication channels." This process consists of five steps: awareness, persuasion, decision, implementation, and confirmation. The diffusion process highlights whether a new idea is accepted through the first three steps: understanding, persuasion, and decision-making. The study also identifies four important components: innovation, communication channels, time, and social systems.

Unified Theory of Acceptance and Use of Technology (UTAUT)

The Unified Theory of Acceptance and Use of Technology (UTAUT) by Venkatesh et al,[17] explains the acceptance of technology by individuals or organizations. UTAUT identifies four core factors influencing behavioral intention: performance expectancy, effort expectancy, social influence, and facilitating conditions. These factors impact both the intention to use and actual usage behavior. Control variables—such as gender, age, experience, and voluntariness of use—also affect both behavioral intention and usage intention.[3]

To refine and update the theory, researchers have developed the UTAUT2 model, which builds on UTAUT1 by integrating additional factors such as hedonic motivation, price value, and habit. It also establishes a link between facilitating conditions and behavior, enhancing the understanding of technology acceptance in various contexts.[3]

Organizational Culture Model (2010)

Innovation culture refers to the values, beliefs, and behaviors that encourage and support creativity and innovation within an organization. According to Denison organizational culture theory, this theory posits that an organization's culture significantly impacts its innovation capability.[18] When a business possesses a strong innovation culture, it fosters risk-taking, collaboration, and open communication. Furthermore, research integrates with the Dynamic Capability Framework, a management theory that describes a company's ability to adapt and innovate based on internal and external resources in response to market changes. It encompasses the ability to integrate, build, and reconfigure resources flexibly, as well as to learn continuously in order to respond swiftly to environmental changes. Dynamic capabilities are responsible for enabling organizations to integrate, mobilize, and reconfigure their resources and capabilities to adapt to rapidly changing environments. Therefore, dynamic

capabilities are processes that allow an organization to realign its strategies and resources to achieve sustainable competitive advantage and superior performance in fast-changing contexts.[19] These theoretical foundations can provide deeper insights into how innovation culture and perceived costs operate within an organizational context and their influence on the innovation process.

2.2. Research Methodology

2.2.1. Research Methods

The author employs both qualitative and quantitative research methods. After identifying the research gap, the author conducted in-depth interviews with five subjects, including one manager from an office and four experts. The study conducted in-depth interviews with five participants, including one manager from the office and four experts, two of whom were interviewed directly at the office and two online via Zalo. The interviewed experts possess extensive experience in the fields of business management and logistics. They are researchers with deep knowledge of enterprise management and innovation management. The experts have made significant contributions to the field and expressed a keen interest in the issues of innovation within organizations, recognizing them as critical factors. Each interview lasted approximately 30 minutes. The results from the in-depth interviews indicated that all five respondents agreed on the influence of performance expectancy, effort expectancy, social influence, facilitating conditions, perceived cost, and innovation culture on the innovation activities of the enterprise. An interview with a representative from Hoang Thu Co., Ltd. was conducted to gather practical insights into the company's operations, focusing on the export of cassava powder to the Chinese market. Additionally, the involvement of academic experts clarified essential indicators and validated the initial research assumptions, ensuring the accuracy and objectivity of the measurement tools. The combination of academic perspectives and practical experience contributed to refining the measurement scale with clear indicators, enhancing the reliability and applicability of the research results.

According to the assessments of experts and managers, the major challenges facing technological innovation activities of businesses using seaport services in Binh Dinh province include low technological capabilities, limited skills and competencies of employees, and scarce financial resources. To overcome these issues, the experts suggested accelerating the development of a culture of innovation, promoting digital transformation, enhancing employee capabilities, and focusing on seeking investment capital for technological innovation, as well as support from state agencies.

After conducting in-depth interviews with experts, the author organized an online focus group discussion via Google Meet with 11 participants, including 5 managers from businesses utilizing seaport services and 6 economic experts from Gia Lai province. The author employed a focus group discussion method to gather information from the management experts. The questions were designed to encourage open discussions, and with the participants' consent, the author recorded the sessions and utilized content analysis methods to code and categorize the collected information. Ultimately, the author identified six key dimensions influencing the technological innovation activities of businesses using seaport services.

The results of the focus group discussion revealed that all 11 respondents agreed that the factors of performance expectancy, effort expectancy, social influence, facilitating conditions, perceived cost, and innovation culture have a significant impact on the technological innovation activities of businesses utilizing seaport services in Gia Lai province. Therefore, the author decided to retain all these factors to ensure a comprehensive and objective research model. Through discussions with experts and managers, the author employed a focus group method to gather information from management professionals. The questions were designed to encourage open dialogue, and with the participants' consent, the author recorded the sessions and utilized content analysis methods to code and categorize the collected information. Ultimately, the author identified six key dimensions influencing the technological innovation activities of businesses using seaport services.

Building on the results of the qualitative research, including the developed model, hypotheses, and measurement scales, the author proceeded with quantitative research, which consisted of two phases: preliminary quantitative research and formal quantitative research. To test the constructed questionnaire, the research team conducted preliminary quantitative research by surveying a sample of 50 customers who utilize e-commerce services. The collected data were

analyzed using SPSS26, PLSmart3, Amos24 software to assess the sample statistics, evaluate the reliability of the measurement scale (using Cronbach's Alpha), and conduct exploratory factor analysis (EFA), confirmatory factor analysis (CFA). Following the analysis and discussion of the research results, the team will proceed with the formal research phase.

The preliminary research phase aims to test the constructed questionnaire through a survey conducted with 30 companies that use port services in Quy Nhon City. The results of the analysis and discussion will be used to adjust and refine the questionnaire to ensure accuracy before initiating the formal research.

The formal quantitative research phase will be carried out by surveying a sample of 158 customers using e-commerce services. The collected data will be analyzed using SmartPLS software to measure the relationships between observed variables and latent constructs, thereby evaluating the research model.

2.2.2. Research Model and Hypotheses

Research Model

Based on the Technology Acceptance Model (TAM), the Innovation Diffusion Theory (IDT), and the Unified Theory of Acceptance and Use of Technology (UTAUT), this research builds on previous studies and combines them with Denison's Organizational Culture Theory and Dynamic Capabilities (DC) Theory. From this foundation, the study proposes and explores a new variable: innovation culture, which has not been addressed in previous research, thereby expanding the existing theoretical framework. This new analytical framework helps to gain a better understanding of the current and future state of innovation within organizations. These contributions not only enrich existing knowledge but also open up new research directions for future studies, facilitating the development of deeper theoretical models and practical guidance for promoting innovation in organizational contexts.

The proposed model incorporates several key constructs and relationships, leading to the following hypotheses:

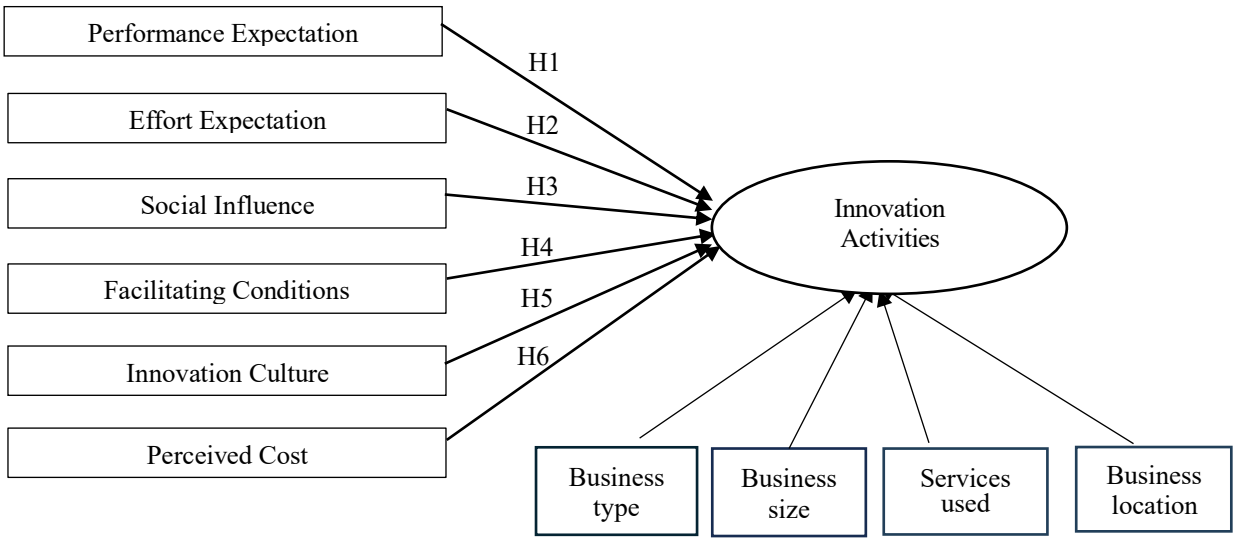

Figure 1. Research Model of Factors Influencing Technology Innovation Activities of Enterprises Utilizing Port Services

(Source: Proposed by the Author)

Research Hypotheses

H1: Performance expectancy has a positive impact on technological innovation activities.

H2: Effort expectancy positively influences technological innovation activities.

H3: Social influence positively affects technological innovation activities.

H4: Facilitating conditions have a positive impact on technological innovation activities.

H5: Innovation culture positively influences technological innovation activities.

H6: Perceived cost positively affects technological innovation activities.

Measurement Scale Development

The developed measurement scale is based on related studies, including those by Venkatesh et al,[17] and incorporates feedback from experts following group discussions. The independent variable consists of six factors with 23 observed variables. This framework is also derived from the works of Joung-Rae Kim and Sang-Jik Lee,[20] Zaouia Abdellah,[21] Dimitra Skoumpopoulou,[22] and D.T.T.Anh.[12] Performance Expectancy (PE) Comprised of four observed variables PE1, PE2, PE3, PE4; Effort Expectancy (EE) Comprised of four observed variables EE1, EE2, EE3, EE4; Social Influence (SI) Comprised of three observed variables SI1, SI2, SI3; Facilitating Conditions (FC) Comprised of four observed variables FC1, FC2, FC3, FC4; Innovation Culture (IC) Based on Venkatesh et al and expert opinions, consisting of three observed variables IC1, IC2, IC3;[17] Perceived Cost (PC) Comprised of five observed variables PC1, PC2, PC3, PC4, PC5 and Technological Innovation Activities (IA) Derived from previous research, consisting of three observed variables IA1, IA2, IA3 by Venkatesh et al.[17]

Table 1. Measurement Scale for Studying Factors Influencing Technological Innovation Activities of Enterprises Utilizing Port Services in Binh Dinh Province

Factor	Symbol	Studies That Have Utilized Them
Performance Expectation	PE	Joung-Rae Kim and Sang-Jik Lee,[20] Zaouia Abdellah,[21] Dimitra Skoumpopoulou,[22] D.T.T.Anh.[12]
Effort Expectation	EE	Joung-Rae Kim and Sang-Jik Lee,[20] Zaouia Abdellah,[21] Dimitra Skoumpopoulou,[22] D.T.T.Anh.[12]
Social Influence	SI	Joung-Rae Kim and Sang-Jik Lee,[20] Zaouia Abdellah,[21] Dimitra Skoumpopoulou,[22] D.T.T.Anh.[12]
Facilitating Conditions	FC	Joung-Rae Kim and Sang-Jik Lee,[20] Zaouia Abdellah,[21] Dimitra Skoumpopoulou,[22] D.T.T.Anh.[12]
Innovation Culture	IC	Venkatesh et al,[17] and Expert Opinions
Perceived Cost	PC	Venkatesh et al,[17] D.T.T.Anh [12]
Innovation Activities	IA	Venkatesh et al.[17]

(Source: Compiled and proposed by the author)

2.3. Research Results

The preliminary research helped identify important variables, develop the survey instrument, and minimize risks, thus providing a solid foundation for the formal study. The survey was conducted with 30 participants, yielding 30 valid questionnaires. The results of the preliminary research indicate that the measurement scale is suitable for evaluation and conducting the formal study, with the findings as follows:

2.3.1. Description of the Research Sample

The study conducted a survey of 158 enterprises utilizing port services. The research sample was distributed according to the size of the enterprises, comprising 56 large enterprises and 102 medium and small enterprises. In terms of business types, there were 43 single-member limited liability companies (LLCs) and 54 limited liability companies with two or more members, while the remainder consisted of other types of businesses. Additionally, the sample surveyed included enterprises using transportation services, loading and unloading services, warehousing services, and other services, primarily located in Quy Nhon City.

The structure of the survey sample is relatively aligned with the actual situation, and the survey was conducted online using Google Forms. The study employed various analytical techniques using SPSS 26.0, Amos 24 and SmartPLS 3 for data processing and issue identification. This included statistical analysis of the research sample, assessment of the reliability of the measurement scale (Cronbach's Alpha), exploratory factor analysis (EFA), and model fit analysis.

2.3.2. Evaluation of the Measurement Model

Using SmartPLS 3, the quality of observed variables (indicators), reliability, convergent validity, and discriminant validity of the

measurement scales were assessed Henseler and Sarstedt.[23]

➢ *Quality of Observed Variables*

The results indicate that the observed variables have loading factors ranging from 0.804 to 0.948 (> 0.708), thus ensuring the quality of these observed variables.

Table 2. Outer Loadings

	EE	FC	IC	PC	PE	SI	IA
EE1	0.877						
EE2	0.828						
EE3	0.822						
EE4	0.804						
FC1		0.921					
FC2		0.910					
FC3		0.883					
FC4		0.917					
IC1			0.946				
IC2			0.948				
IC3			0.870				
PC1				0.906			
PC2				0.852			
PC3				0.834			
PC4				0.928			
PC5				0.922			
PE1					0.924		
PE2					0.937		
PE3					0.949		
PE4					0.938		
SI1						0.896	
SI2						0.900	
SI3						0.884	
IA1							0.942
IA2							0.946
IA3							0.947

(Source: SmartPLS3 processing results, 2025)

Reliability of the Measurement Scale

The reliability of the measurement scale is typically assessed through two indices: Composite Reliability (CR) and Cronbach's Alpha (CA). The condition for both of these coefficients to indicate high reliability is that they should be greater than 0.70.

The results indicate that the Composite Reliability (CR) of the research variables has a minimum value of 0.901, which exceeds the minimum threshold of 0.70. Additionally, the Cronbach's Alpha (CA) coefficients for the research variables are also all above the minimum threshold of 0.70, ranging from 0.855 to 0.954. This demonstrates that the measurement scales possess high reliability.

Table 3: Assessment of Measurement Scale Reliability

	CA	CR
EE - Effort Expectation	0.855	0.901
FC- Facilitating Conditions	0.929	0.949
IC- Innovation Culture	0.911	0.944
PC- Perceived Cost	0.933	0.950
PE- Performance Expectation	0.954	0.966
SI- Social Influence	0.874	0.922
IA- Innovation Activities	0.940	0.961

(Source: SmartPLS3 processing results, 2025)

➢ *Assessment of Convergent Validity of the Measurement Scale*

able 4: Results of Convergent Validity Assessment

	AVE
EE - Effort Expectation	0.694
FC- Facilitating Conditions	0.824
IC- Innovation Culture	0.850
PC- Perceived Cost	0.791
PE- Performance Expectation	0.878
SI- Social Influence	0.798
IA- Innovation Activities	0.893

(Source: SmartPLS3 processing results, 2025)

The results of the convergent validity assessment indicate that the Average Variance Extracted (AVE) values range from 0.791 to 0.893, all exceeding the minimum threshold of 0.50. Therefore, it can be concluded that the measurement scales for the research variables possess adequate convergent validity.

Assessment of Discriminant Validity

Discriminant validity of the measurement scales is evaluated through three criteria: Fornell-Larcker criterion, cross-loading coefficients, and Heterotrait-Montrait (HTMT) ratio.

(i) Fornell-Larcker Criterion

Table 5: Results of Discriminant Validity Assessment Using Fornell-Larcker Criterion

	EE	FC	IC	PC	PE	SI	IA
EE	**0.833**						
FC	0.137	**0.808**					
IC	0.162	0.407	**0.822**				
PC	0.067	0.409	0.302	**0.849**			
PE	0.185	0.589	0.393	0.367	**0.837**		
SI	0.126	0.455	0.292	0.321	0.556	**0.833**	
IA	0.343	0.570	0.510	0.413	0.591	0.487	**0.845**

(Source: SmartPLS3 processing results, 2025)

From the results above, the author observes that the square root of the Average Variance Extracted (AVE) values (the numbers on the diagonal, bolded) for all constructs are 0.822 or higher and exceed the correlation coefficients of the constructs (the corresponding non-bolded numbers in the same column). Thus, the measurement scales meet the Fornell-Larcker criteria for discriminant validity.

(ii) Cross-Loading Coefficients

Cross-loading coefficients measure the extent to which an observed variable "loads" onto a factor that is not its primary factor. This evaluation is crucial for establishing discriminant validity, as high cross-loading values on non-target factors may indicate an overlap between constructs.

Table 6: Results of Discriminant Validity Assessment Using Cross-Loading Coefficients

	EE	FC	IC	PC	PE	SI	IA
EE1	**0.877**	0.112	0.082	0.096	0.238	0.177	0.321
EE2	**0.828**	0.120	0.096	0.085	0.153	0.153	0.253
EE3	**0.822**	0.160	0.247	0.050	0.149	0.056	0.330
EE4	**0.804**	0.041	0.087	0.032	0.037	0.016	0.207
FC1	0.137	**0.921**	0.327	0.348	0.526	0.447	0.492
FC2	0.201	**0.910**	0.401	0.412	0.556	0.388	0.598
FC3	0.088	**0.883**	0.377	0.384	0.540	0.375	0.475
FC4	0.055	**0.917**	0.368	0.332	0.511	0.446	0.485
IC1	0.136	0.354	**0.946**	0.284	0.327	0.246	0.460
IC2	0.132	0.350	**0.948**	0.278	0.338	0.276	0.448
IC3	0.177	0.415	**0.870**	0.271	0.415	0.282	0.498
PC1	0.103	0.368	0.263	**0.906**	0.351	0.293	0.373
PC2	0.083	0.454	0.312	**0.852**	0.356	0.291	0.345
PC3	0.002	0.308	0.194	**0.834**	0.265	0.272	0.335
PC4	0.057	0.394	0.318	**0.928**	0.335	0.294	0.406
PC5	0.049	0.296	0.248	**0.922**	0.324	0.278	0.374
PE1	0.147	0.581	0.380	0.384	0.924	0.488	0.571
PE2	0.202	0.525	0.343	0.322	**0.937**	0.540	0.553
PE3	0.159	0.508	0.395	0.333	**0.949**	0.546	0.541
PE4	0.186	0.591	0.357	0.336	**0.938**	0.512	0.550
SI1	0.100	0.387	0.254	0.335	0.472	**0.896**	0.450
SI2	0.141	0.450	0.313	0.264	0.507	**0.900**	0.461
SI3	0.095	0.378	0.206	0.258	0.515	**0.884**	0.387
IA1	0.287	0.552	0.493	0.417	0.546	0.434	**0.942**
IA2	0.328	0.503	0.487	0.405	0.559	0.455	**0.946**
IA3	0.357	0.559	0.467	0.351	0.571	0.490	**0.947**

(Source: SmartPLS3 processing results, 2025)

The results indicate that all outer loadings of the observed variables are greater than the cross-loadings. This suggests that the variables do not violate the discriminant validity.

(iii) HTMT Coefficients

The Heterotrait-Monotrait (HTMT) ratio assesses the degree to which two constructs share variance. A lower average of the cross-loading coefficients indicates that the latent variable in question shares less variance with other latent variables. In this case, the constructs can be deemed to have discriminant validity.

The HTMT coefficients range from 0.091 to 0.624, all below the threshold of 0.90. This

suggests that the measurement scales for the variables in the research model exhibit sufficient discriminant validity.

Table 7: Results of Discriminant Validity Assessment Using HTMT Coefficients

	EE	FC	IC	PC	PE	SI	IA
EE							
FC	0.140						
IC	0.173	0.438					
PC	0.091	0437	0.325				
PE	0.191	0.624	0.419	0.389			
SI	0.146	0.504	0.322	0.354	0.610		
IA	0.371	0.604	0.550	0.441	0.624	0.534	

(Source: SmartPLS3 processing results, 2025)

➢ *Evaluating Model Fit*

The assessment of the CFA (Confirmatory Factor Analysis) model aims to evaluate whether the theoretical model concerning both independent variables (latent factors) and their observed variables (measured variables) aligns with actual data. CFA tests the pre-defined factor structure, allowing for confirmation of whether the measured variables accurately reflect their corresponding independent variables. The purpose of CFA is to determine if the observed variables indeed measure the latent factors (independent variables) according to the initial hypotheses, prior to using this model to analyze relationships among structural variables in a larger Structural Equation Model (SEM).

If the declared factor structures are appropriate, the model fit will be ensured; conversely, if the declared factor structures are not appropriate, the model fit will be violated. Model fit evaluation essentially assesses the internal factor structure and the relationships among the factors. Factors that can reduce model fit include: overlapping observed variables within a factor, observed variables in a factor that weakly explain the parent factor, observed variables belonging to one factor but strongly explaining another, and multicollinearity between factors.

Some fundamental indicators of model fit include Chi-square/df, GFI, CFI, TLI, and RMSEA. According to Hair et al in "Multivariate Data Analysis, 7th edition," the indicators considered for assessing Model Fit are as follows: CMIN/df ≤ 2 is good, CMIN/df ≤ 5 is acceptable; CFI ≥ 0.9 is good, CFI ≥ 0.95 is very good, CFI ≥ 0.8 is acceptable; GFI ≥ 0.9 is good, GFI ≥ 0.95 is very good; RMSEA ≤ 0.08 is good, RMSEA ≤ 0.03 is very good.[24]

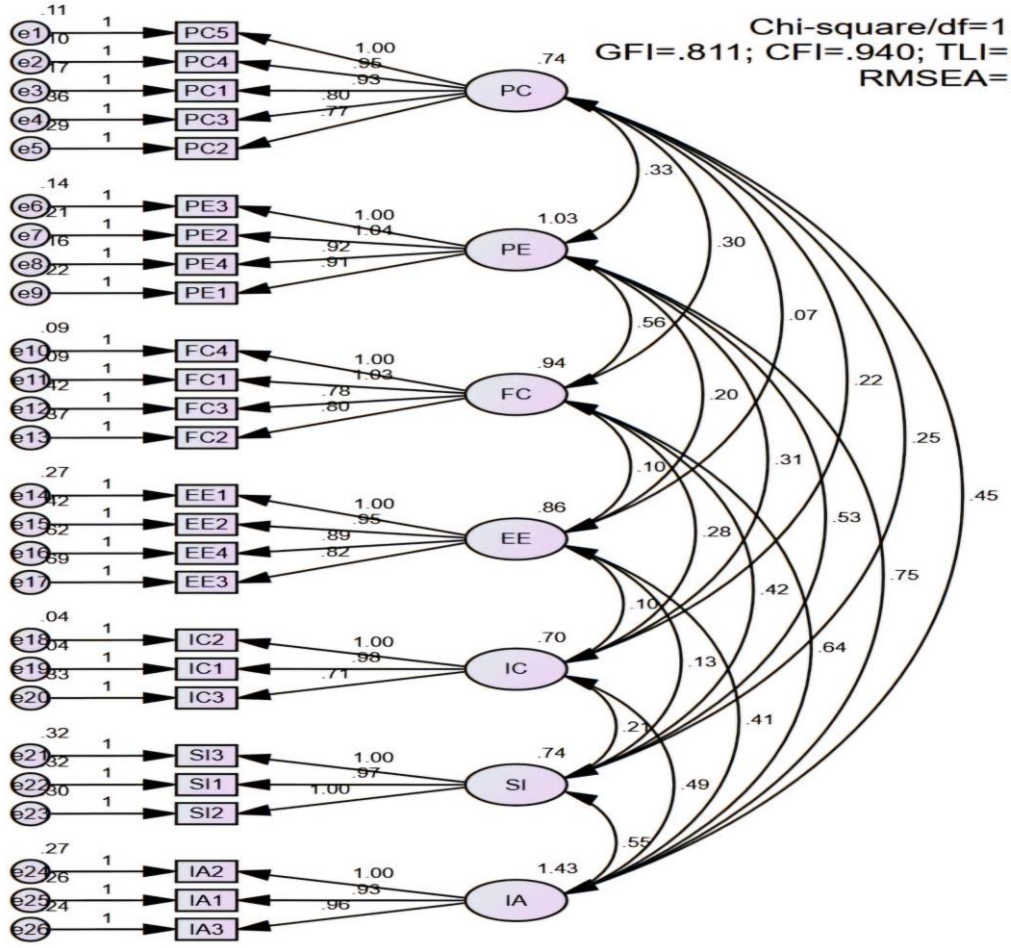

Figure 2: Model Fit Evaluation Results

(Source: Amos 24 processing results, 2025)

The results indicate that with a CMIN/df (Chi-square/df) of 1.809 (less than the threshold of 2), the model is good and appropriate. Both the Tucker-Lewis Index (TLI) at 0.930 and the CFI at 0.940 (both exceeding 0.9) qualify the model as having relatively good fit. Additionally, the RMSEA value of 0.072 (less than 0.08) indicates good model fit. In summary, all evaluation indicators suggest that this model is adequately fit and compatible with the data.

2.3.3. Model Evaluation Results

➢ *Variance Inflation Factor (VIF)*

Table 8: Variance Inflation Factor (VIF)

	EE	FC	IC	PC	PE	SI	IA
EE							1.047
FC							1.744
IC							1.288
PC							1.273
PE							1.913
SI							1.522
IA							

(Source: SmartPLS3 processing results, 2025)

The author uses the Variance Inflation Factor (VIF) to assess the multicollinearity phenomenon among the independent variables in the model. According to the results, the VIF values range from 1.047 to 1.913, satisfying the condition of being less than 5. Therefore, the research model is deemed appropriate and is not affected by multicollinearity issues.

➢ *Evaluation of Adjusted R-squared*

The Adjusted R-squared coefficient assesses the goodness of fit of the model concerning the dependent variable. It adjusts the R-squared value based on the number of predictors in the model, providing a more accurate measure of how well the independent variables explain the variance in the dependent variable.

Table 9: Adjusted Coefficient of Determination

Model	R Square	Adjusted R Square
IA	0.554	0.536

(Source: SmartPLS3 processing results, 20255)

The results of the data analysis show that the Adjusted R-squared value is 0.536. This indicates

that the independent variables explain 53.6% of the variance in the dependent variable. Therefore, the model is deemed appropriate.

➢ *Evaluation of the f^2 Effect Size*

In addition to the Adjusted R-squared value, the f^2 effect size is used to assess the impact of the independent variables on the dependent variable. The results indicate that the variables have a small effect on IA, with corresponding f^2 values of 0.100, 0.147, and 0.097. These values are all greater than 0.02 and less than 0.15, indicating a small level of influence.

➢ *Results of Hypothesis Testing for Relationships in the Model*

The results of the model testing indicate that the independent variables EE, FC, IC, PC, PE, and SI all have a direct influence on IA, as the p-values from the t-tests for these variables are all less than 5%. Furthermore, all variables exert a positive effect on IA, as evidenced by the coefficients (β) being greater than 0.

Table 10: Results of Model Testing

	Original Sample (O)	P Values
EE -> IA	0.212	**0.000**
FC -> IA	0.206	**0.005**
IC -> IA	0.229	**0.000**
PC -> IA	0.121	**0.026**
PE -> IA	0.219	**0.016**
SI -> IA	0.139	**0.044**

(Source: SmartPLS3 processing results, 2025)

The phenomenon of multicollinearity was assessed using the VIF (Variance Inflation Factor), and the results indicated that it does not occur. The findings show that Innovation Culture has a strong impact (0.229), followed by Performance Expectancy (0.219), Effort Expectancy (0.212), Facilitating Conditions (0.206), Social Influence (0.139), and finally Perceived Cost (0.121). However, these six influencing factors are significant, and there are many other factors that also affect the technology innovation activities of businesses utilizing port services in Binh Dinh province.

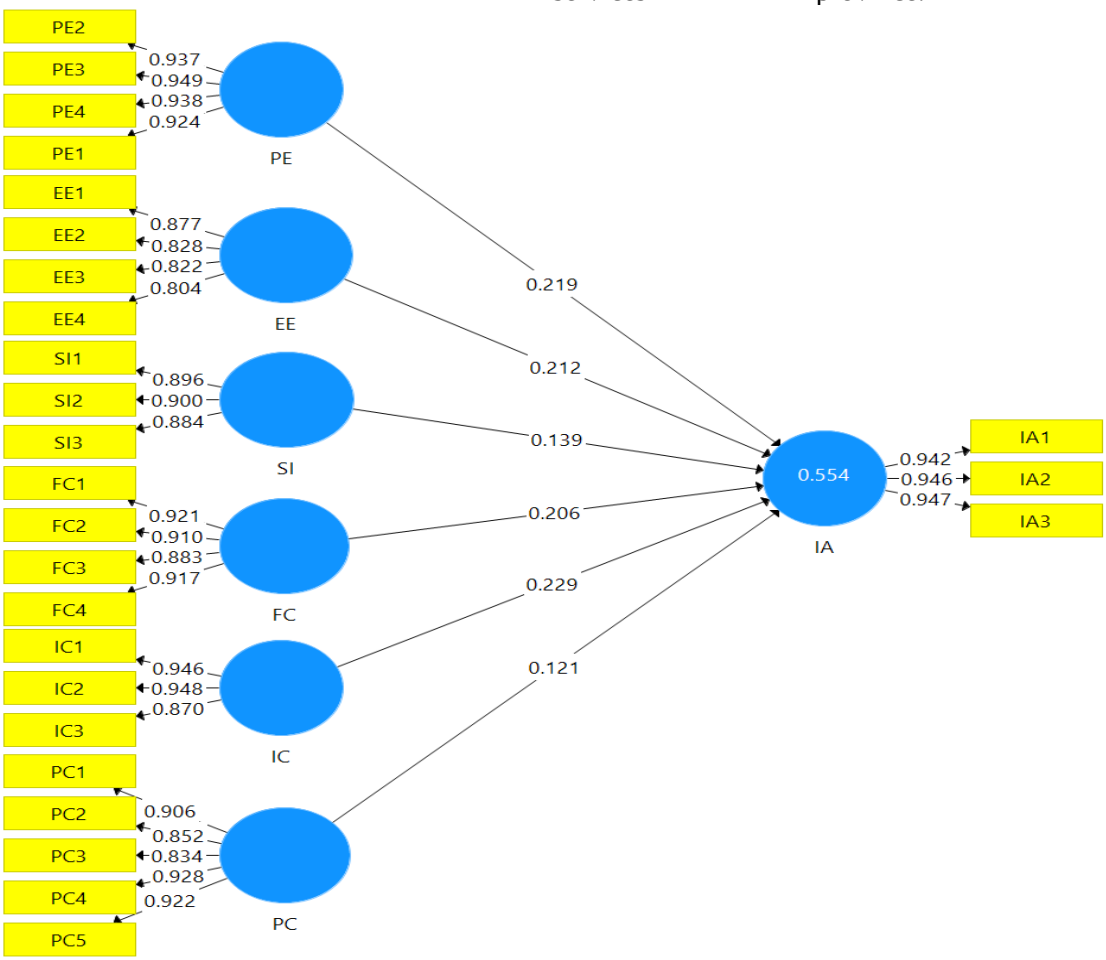

Figure 3: Model of Factors Influencing Technology Innovation Activities of Enterprises Utilizing Port Services in Binh Đinh Province

(Source: SmartPLS3 processing results, 2025)

Based on the results of the model assessment conducted using SmartPLS 3, it is evident that the factors influencing technology innovation activities of businesses utilizing port services in Binh Dinh province include Innovation Culture, Performance Expectancy, Effort Expectancy, Facilitating Conditions, Social Influence, and Perceived Cost. The model representing these influencing factors can be expressed as follows:

Technology Innovation Activity = 0.121 x Perceived Cost + 0.219 x Performance Expectancy + 0.206 x Facilitating Conditions + 0.212 x Effort Expectancy + 0.229 x Innovation Culture + 0.139 x Social Influence

The research results indicate that innovation culture is a crucial factor influencing the technological innovation activities of businesses utilizing seaport services in Gia Lai, with the highest regression coefficient of 0.229. This means that if a business's innovation culture increases by 1 point, its technological innovation activity will increase by 0.229 points. This finding suggests that an innovation culture fosters creative thinking within the organization. Employees are encouraged to propose new ideas, improve work processes, and develop service products. Additionally, businesses with an innovation culture are more willing to experiment with new technologies to enhance performance.

Moreover, the government's orientation to encourage businesses to undergo digital transformation and innovation has facilitated investments in innovation and training employees to adapt to new technologies. When the culture supports creativity and risk acceptance, other factors such as perceived costs become less obstructive, allowing organizations to maximize innovation opportunities. Conversely, if the culture is weak, even good ideas may be rejected due to concerns about costs and risks.

The second most influential factor after innovation culture is performance expectancy, with a regression coefficient of 0.219. This means that if a business's performance expectancy increases by 1 point, its technological innovation activity will increase by 0.219 points. In practice, technology investments are expected to yield effective results in terms of productivity and work performance.

Additionally, the desire for technology to be user-friendly enables employees to access and utilize it more effectively, leading to an effort expectancy factor with a regression coefficient of 0.212. Factors such as facilitating conditions, perceived cost, and social influence have a lower impact but still positively influence innovation activities.

Perceived cost significantly affects businesses' decisions regarding the adoption of innovations. If costs are perceived as too high, businesses may reject creative ideas, even if they hold potential. Therefore, organizations need to carefully evaluate the benefits against costs before implementing any innovations.

In summary, innovation culture has the most substantial impact as it lays the foundation for all innovation activities within the organization.

3. CONCLUSION

This study investigates the factors influencing technology innovation activities of businesses utilizing port services in Binh Dinh Province. The results indicate six significant factors: Performance Expectancy (PE), Effort Expectancy (EE), Social Influence (SI), Facilitating Conditions (FC), Innovation Culture (IC), and Perceived Cost (PC). Among these, Innovation Culture (IC) has the greatest impact, while Social Influence (SI) has the least.

With the upcoming merger of Binh Dinh Province with the former Gia Lai Province, effective from July 1, 2025, it is noteworthy that Gia Lai does not have a seaport. Consequently, businesses in this area primarily rely on port services in the former Binh Dinh. Based on the study's findings, the author proposes several recommendations to enhance technology innovation for businesses utilizing port services in Binh Dinh, which can also extend to companies in the newly formed Gia Lai province.

Given the demands of the logistics sector and port services for efficient use of port services, cost-saving logistics, and economic development for businesses in the port sector, it is essential for both service providers and users to innovate technology. This innovation should aim towards establishing smart and integrated port services.

This study suggests several key directions for businesses, specifically those using port services, to foster technology innovation in the near future:

First: Building an Innovation Culture within the Organization:

The research emphasizes that Innovation Culture (IC) has the most significant impact on technological innovation activities. With a β value of 0.229 for Innovation Culture, the highest among the β values of the factors, this indicates that organizations need to invest in building and maintaining a strong culture of innovation.

Managers should implement training programs and activities that encourage creativity within the workforce. Building collaboration among departments is essential, and organizations should promote team activities and inter-departmental projects. This can enhance the sharing of knowledge and ideas. Leaders should develop policies that support innovation, such as financial incentives for innovative ideas and facilitating employee experimentation with new solutions. Technological innovation encompasses not only hardware but also software and human factors. Therefore, it is necessary to enhance employees' skills and awareness of technology. Businesses should foster an innovation culture that encourages creativity and allows for the application of new and improved ideas in production processes.

Second: Evaluating Technology Performance Before Innovation:

Performance Expectation (PE) significantly influences technological innovation, with a coefficient of 0.219. Businesses need to focus on assessing and selecting appropriate technologies to achieve optimal performance, including conducting feasibility assessments before investing in technology. Organizations can establish performance metrics such as labor productivity, error rates in production processes, order processing times, and customer satisfaction levels. Additionally, businesses could employ tools such as SWOT analysis to gain a clear understanding of their current situation, conduct surveys to gather feedback from employees about existing workflows and challenges they face, which can provide insights into performance and areas for improvement. Performance can also be analyzed through data on costs and forecasting results. Alternatively, small-scale experiments with new technologies in specific processes can be conducted to evaluate their impact before broad implementation, as technological innovation is a crucial step to ensure that businesses can fully leverage the opportunities that new technologies offer.

Third: Proactively Managing Resources and Conditions for Technology Innovation:

Facilitating Conditions (FC) significantly affect the innovation activities of enterprises, with a coefficient of 0.206. Businesses need to proactively manage resources, such as ensuring substantial financial investments, enhancing labor skills, and improving infrastructure to ensure that the technological innovation process is adequately prepared and applied effectively. To select technology that aligns with the capabilities of the enterprise and enhances effectiveness, organizations should identify existing resources, including human resources, financial assets, infrastructure, and technology. This helps to recognize the capacity for implementing and adopting new technologies. Simultaneously, it is essential to assess the skills and knowledge of employees to identify gaps that need training before the adoption of new technology. Businesses can research existing technologies in the market, comparing features, advantages, and disadvantages of each solution. Additionally, they may seek opinions and evaluations from industry experts to gain insights into suitable technologies. The selection of technology that aligns with the enterprise's capabilities is a necessary process to optimize performance and achieve business objectives.

Finally: Integrating Multiple Solutions: In addition to factors like Innovation Culture (IC), Performance Expectancy (PE), and Facilitating Conditions (FC), Effort Expectancy (EE), Social Influence (SI), and Perceived Cost (PC) also affect technology innovation. Therefore, businesses should actively monitor technology trends, digital transformation, and advancements relevant to the logistics and port sectors to ensure that their innovation efforts align with market trends and provide competitive advantages. Additionally, attention should be paid to gathering information on technology investment costs and insights from experts or businesses that have previously adopted technology to assess the effectiveness of investments and choose technologies suitable for their financial capabilities.

In conclusion, this research has established and assessed a model of factors influencing technology innovation activities of businesses utilizing port services in Binh Dinh province. The study validated the model, reaffirming the factors impacting technology innovation. However, it primarily focused on businesses using port services without comparing them to service providers. Furthermore, the sample size was limited, and the study was conducted within the confines of the former Binh Dinh province. The analytical tools employed were also limited to SPSS 26.0 and SmartPLS 3. Therefore, future research could expand to include a broader range of businesses, cover larger geographical areas, and utilize a variety of more advanced statistical analytical tools.

Acknowledgments

REFERENCES

1. Vieites, A.G. and Calvo, J.L. A Study on the Factors That Influence Innovation Activities of Spanish Big Firms, *Technology and Investment*, **2011**, *2(1)*, 8-19.

2. Gnyawali, D. R., & Park, B.-J. Co-opetition and technological innovation in small and medium-sized enterprises: A multilevel conceptual model, *Journal of Small Business Management*, **2009**, *47*(3), 308-330.

3. Thong, J. Y. L. An integrated model of information systems adoption in small businesses, *Journal of Management Information Systems*, **2015**, *15(4)*, 187-214.

4. Azarmi, Davar. Factors Affecting Technology Innovation and Its Commercialisation in Firms, *Modern Applied Science*, **2016**, *10(7)*, 36-48.

5. Rangus, K., & Slavec, A. The interplay of decentralization, employee involvement and absorptive capacity on firms' innovation and business performance. *Technological Forecasting & Social Change,* **2017**, *120*, 195-203.

6. Yang, Y., Zhong, M., Yao, H., Yu, F., Fu, X., & Postolache, O. Internet of things for smart ports: Technologies and challenges, *IEEE Instrumentation & Measurement Magazine,* **2018**, *21(1)*, 34-43.

7. Sun, X. Digitalization in the port industry from the perspectives of bibliometric analysis, *The Asian Journal of Shipping and Logistics*, **2023**, 39(3), 57-62.

8. P.T.Yen and N.T.H.Giang. Research on Criteria Influencing the Adoption of Digital Technology Towards Smart Ports, *Journal of Maritime Science and Technology*, **2022**, *70*, 101-105.

9. L.S.Tung, "Investigation of Factors Affecting Digital Transformation Activities in Logistics Enterprises in Hai Phong Area, *Journal of Maritime Science and Technology*, **2022**, *70*, 67-77.

10. N.M.Cuong and P.V.Hung, Study on the Current Status of Digital Transformation in Shipping Enterprises, *Journal of Maritime Science and Technology*, **2023**, 73, 79-85.

11. N.T.A.Van and N.K.Hieu. Factors Influencing Technological Innovation of Small and Medium Enterprises, *Ho Chi Minh city Open university of Science journal - Economics and Business administration*, **2021**, *15(3)*,167-179

12. D.T.T.Anh. *Factors Affecting the Intention of Technological Innovation among Small and Medium-Sized Enterprises in Ho Chi Minh City: A Study of the Food Processing Industry*. Doctoral Dissertation, University of Economics Ho Chi Minh City, **2022**.

13. Venkatesh, V., Morris, M., Davis, G. B., and Davis, F. D. User acceptance of information Technology: toward a unified view. *Management Information Systems Quarterly*, **2003**, *27(3)*, 425-478.

14. N.D.Dau and N.X.Tai. *Textbook on Technology Management*. National Economics University Press, Ha Noi, **2014**.

15. Davis, F. D, Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology, *MIS Quarterly*, **1989,** *13(3)*, 319-340.

16. Rogers EM, *Diffusion of Innovations (5th edition)*, Free Press, New York, **2003**.

17. Venkatesh, James Y.L. Thong and Xin Xu, Consumer acceptance and use of information technology: extending the unified theory of acceptance and use of technology, *MIS Quaterly,* **2012**, *36(1)*, 157-178.

18. Denison. "Organizational Culture & Employee Engagement: What's the Relationship?" *www.denisonculture.com*, **2010**, *4(3)*, 415-419.

19. Teece, D.J., Pisano, G. & Shuen, A. Dynamic capabilities and strategic management. *Strategic Management Journal*, **1997**, *18(7),* 509-533**.**

20. Joung-Rae Kim, Sang-Jik Lee, Factors Affecting Technology Acceptance of Smart Factory, *Journal of Information Technology Applications and Management,* **2020***, 27(1)*, 75-95.

21. Zaouia Abdellah, Achargui AmineArrahmane, Jalil Fatima, *factors Affecting Adoption of FLOSS ERP System by SMEs' Directors and Managers in Developing Countries,* International Colloquium on Information Science and Technology, IEEE, 4th edition, Maroc, **2016**, 25-30.

22. Dimitra Skoumpopoulou, Adam Wong, Peggy Ng and Man Fung Lo, Factors that affect the acceptance of new technologies in the workplace: a cross case analysis between two universities, *International Journal of Education and Development using Information and Communication Technology (IJEDICT),* **2018**, *14(3)*, 209-222.

23. Henseler, J., Sarstedt, M., Goodness – of – fit indices for partial least squares path modeling, *Computational Statistics*, **2013***, 28(2)*, 565–580.

24. Theo Hair et al. *Multivariate Data Analysis,* 7th edition**,** Pearson, New York, **2010**.