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Examining the Intention to Adopt an Online Platform for Freight Forwarding Services in Thailand: A Modified Unified Theory for Acceptance and Use of Technology (UTAUT) Model Approach

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Abstract: *Background*: The freight forwarding industry is undergoing digital transformation through the implementation of online platforms designed to enhance operational efficiency and transparency. Despite these benefits, the adoption of these platforms has been slower than anticipated due to customer concerns and industry-specific challenges. *Methods*: This study investigates the factors influencing the intention to adopt and the actual use of online platforms for freight forwarding services among business customers in Thailand. A modified Unified Theory for Acceptance and Use of Technology (UTAUT) model, incorporating perceived risk, serves as the theoretical framework. Survey data were collected from 400 respondents in managerial or higher-level positions involved in freight shipping within Thai firms and analyzed using a structural equation model (SEM). *Results*: The analysis reveals that performance expectancy, effort expectancy, social influence, and facilitating conditions positively influence adoption intention, while perceived risk negatively impacts it. Firm size moderates the effect of social influence, with a stronger impact observed in larger enterprises. *Conclusions*: The findings offer practical insights for Thai freight forwarders, suggesting strategies to improve customer acceptance and encourage the adoption of online platforms. Addressing the identified factors could lead to improved efficiency and greater integration of digital technologies in the logistics industry.

Keywords: freight forwarding services; online platforms; UTAUT; logistics; Thailand

Citation: Pinyanitikorn, N.; Atthirawong, W.; Chanpuypetch, W. Examining the Intention to Adopt an Online Platform for Freight Forwarding Services in Thailand: A Modified Unified Theory for Acceptance and Use of Technology (UTAUT) Model Approach. *Logistics* **2024**, *8*, 76. https://doi.org/10.3390/logistics8030076

Academic Editors: Tomasz Nowakowski, Artur Kierzkowski, Agnieszka A. Tubis, Franciszek Restel, Tomasz Kisiel, Anna Jodejko-Pietruczuk and Mateusz Zając

Received: 17 May 2024
Revised: 12 July 2024
Accepted: 29 July 2024
Published: 31 July 2024

1. Introduction

The role of freight forwarding services is crucial in enabling international trade by overseeing the intricate process of moving goods across borders for shippers. Acting as intermediaries between exporters/importers and carriers, freight forwarders offer various services, including transportation planning, customs clearance, cargo consolidation, and documentation handling. This industry is characterized by its high fragmentation, with a diverse range of players such as global logistics integrators, regional firms, and local small and medium enterprises (SMEs) competing based on factors like network coverage, specialized knowledge, and customer relations [1–3].

In the current business landscape, the rapid growth of e-commerce and digital technologies has posed challenges for numerous industries, including logistics and shipping [2,4]. To address the changing demands of customers, businesses are innovating their models and improving their value propositions. In the freight forwarding sector, exemplified by companies like DHL and UPS, online platforms have emerged to streamline services for their partners and customers [5]. These platforms are disruptive,

leveraging digital capabilities to provide instant quotations, aggregate capacity, enable real-time tracking, and offer self-service shipment management solutions [2,6].

The digitalization of the freight forwarding industry has given rise to online platforms that provide shippers with real-time quotes, booking, tracking, and document management capabilities [6,7]. These platforms leverage cloud computing, API integration, and data analytics to streamline manual processes, enhance transparency and shipment visibility, and improve operational efficiency [8]. However, despite the potential benefits of these technologies, the adoption of online platforms remains limited in some contexts [9–11]. While global forwarders have introduced online booking and tracking tools in the market, most local firms have been slow to adopt them due to factors such as lack of customer awareness, legacy processes, and resource constraints [12,13]. This variation in adoption rates highlights the differing levels of digital readiness and technology acceptance.

In Thailand, freight forwarders are planning to transition their customers from traditional booking methods through salespersons to an online platform. However, there is no government support for developing a central platform for freight forwarding or other logistics services. As a result, private sectors must individually develop and heavily invest in their platform applications to support their businesses. This initiative aims to improve the service experience and enhance their competitiveness in a highly competitive marketplace.

However, the adoption of online-based freight forwarding service platforms in Thailand remains an innovative and relatively new concept. Despite this, Thailand does not face significant barriers regarding the quality of telecommunication and internet networking, which are sufficient to provide wide-area coverage. Within the Thai industry environment, the primary customers of freight forwarding services are business companies, including both large multinational corporations (MNCs) and, predominantly, small and medium enterprises (SMEs). Therefore, understanding the expectations and concerns of these customer groups regarding the adoption of online-based freight forwarding services within the context of Thai culture is essential. This knowledge is crucial for developing niche platforms that meet customer needs and facilitate the transition to online services.

Several theoretical models have been proposed to explain user acceptance of new technologies; they include the Technology Acceptance Model (TAM), the Theory of Planned Behavior (TPB), and Innovation Diffusion Theory (IDT), and the Unified Theory of Acceptance and Use of Technology (UTAUT) [14]. Among these, the UTAUT, proposed by Venkatesh et al. [15], integrates elements from various prominent models in the context of information systems [14,15]. Compared to other models, the UTAUT offers a more holistic approach by incorporating a wider range of factors and their interactions, making it highly effective in predicting technology acceptance. Additionally, the UTAUT accounts for the moderating effects of gender, age, experience, and voluntariness of use, providing a nuanced understanding of different user groups [15]. While models like TAM focus primarily on perceived usefulness and ease of use [16], the UTAUT's broader scope and consideration of social and contextual factors make it a robust and versatile tool for analyzing technology adoption across various settings. Consequently, the UTAUT has been widely applied in recent research to test factors influencing technology acceptance and adoption across various contexts.

Therefore, the primary aim of this study is to examine the factors that influence firms' intentions to use an online platform for freight forwarding services in Thailand. A significant contribution of this study is the analysis of variables within a modified UTAUT model to determine the effects of various factors related to the adoption of online platforms in the Thai context. This study introduces perceived risk as an additional factor to examine its relationship within the proposed model. Furthermore, interesting moderating variables are suggested to investigate different perspectives among user

groups that may affect their adoption intentions for using information technology in the freight forwarding industry.

The paper is organized as follows: Section 2 reviews the literature and develops the hypotheses of this study. Section 3 describes the methodology. Section 4 presents the data analysis and results. Section 5 provides research discussion and implications. And Section 6 concludes this study.

2. Background Literature and Hypotheses

2.1. The Unified Theory of Acceptance and Use of Technology (UTAUT)

The Unified Theory of Acceptance and Use of Technology (UTAUT) was developed by Venkatesh et al. in 2003 [15]. The UTAUT posits that that four key factors influence the behavioral intention to adopt a technology: performance expectancy (perceived usefulness), effort expectancy (ease of use), social influence (subjective norms), and facilitating conditions (organizational and technical support). The model also includes four moderating variables—gender, age, experience, and voluntariness of use—which are hypothesized to affect the relationships between the predictors and behavioral intention [15].

The UTAUT has been widely applied to study technology adoption across various contexts, including the acceptance of E-commerce platforms [17], work from home technologies during the COVID-19 pandemic [18], implementation of omnichannel marketing in purchasing [19], mobile banking in China [20], E-payment in Yemen [21], student ICT adoption in Ghana [22], customer usage of logistics technologies such as buy-online-and-pickup-in-store (BOPS), smart lockers and drone delivery [23], sustainable usage intention of blockchain in logistics and supply chain management companies [24–26], logistics platform resource integration [27], material procurement in construction companies in India [28], and cloud computing services [29]. These studies have generally confirmed the predictive power of the model while emphasizing the need to adapt it based on the specific technology, regional, and industrial context.

Various studies have proposed modified UTAUT models to examine specific contexts, often by adding or removing independent and moderating variables to the model. In this review, we focus on the adoption of technology within the logistics industry. Additionally, we review the factors used in related contexts, considering the countries involved in the technology adoption. This review aims to identify the most suitable factors for analysis. The related literature on modified UTAUT models for testing the intention to adopt technology in various contexts is summarized in Table 1.

Table 1. The related literature on modified UTAUT models for testing the intention to adopt technology.

Source	Year	Technology	Context	PE	EE	SI	FC	PP	HM	PR	TR	PC	CO	PV	AT	HB	IN	AG	GE	EX	VU	ED	FS	IS
[30]	2013	Security as a service	Germany, Austria, and Switzerland	✓	✓					✓	✓				✓								✓	✓
[29]	2016	Cloud computing services	Germany	✓	✓	✓	✓			✓	✓							✓	✓	✓				
[31]	2019	Big data in supply chain management	Brazil	✓	✓	✓	✓				✓													
[32]	2020	Enterprise resource planning (ERP)	Developing and Asian countries	✓	✓	✓	✓															✓	✓	
[33]	2020	Online technology during COVID-19 quarantine time	Thailand	✓	✓	✓	✓			✓	✓													
[34]	2022	M-payment	Retailers in Egypt	✓	✓	✓	✓			✓	✓							✓	✓			✓		
[35]	2022	Cashless payment system	Thailand	✓	✓	✓				✓	✓													
[36]	2022	Digital health information system	China	✓	✓	✓	✓	✓		✓		✓	✓											
[37]	2022	E-marketplace	Small businesses in India	✓	✓	✓	✓							✓				✓		✓				
[38]	2022	E-retail platforms	Sub-Saharan Africa	✓	✓	✓			✓	✓	✓							✓	✓	✓				
[39]	2022	Fintech	Port's users in Ghana and sub-Saharan Africa	✓	✓	✓	✓		✓					✓		✓		✓						
[26]	2023	Blockchain adoption	Logistics companies in Ho Chi Minh City, Vietnam	✓	✓	✓	✓													✓				
[40]	2023	Mobile pocket software	A logistics company in Indonesia	✓	✓	✓	✓		✓	✓	✓		✓											
[41]	2023	Fintech service	Jeddah, Saudi Arabia	✓	✓	✓	✓			✓	✓	✓					✓							
[42]	2023	Imported spirit flash delivery applications	China			✓				✓						✓	✓					✓		

Note: UTAUT independent variables: PE = performance expectancy; EE = effort expectancy; SI = social influence; FC = facilitating condition. UTAUT moderating variables: AG = age; GE = gender; EX = experience; VU = voluntariness of use. Modified UTAUT independent variables: PP = perceived playfulness; HM = hedonic motivation; PC = privacy concern; PR = perceived risk; TR = trust; CO = perceived cost; PV = perceived vulnerability; AT = attitude; IN = innovativeness; HB = habit. Modified UTAUT moderating variables: ED = educational qualification; FS = firm size; IS = industrial sector.

This study aims to explore perceived risk as an additional influencing factor in the intention to adopt an online platform for freight forwarding services, integrating it into the UTAUT model in alignment with similar recent studies [29,30,33–35,38,40–42]. Additionally, we investigate the potential moderating effects of firm size and user generation on the relationship between the direct factors and the intention to adopt an online platform [29,30,32,34,37,38]. Consequently, the factors influencing the intention to adopt online freight forwarding services are comprehensively reviewed in the following section to develop research hypotheses.

2.2. Development of Influencing Factors toward the Intention to Use an Online Platform for Freight Forwarding Services

The traditional UTAUT model posits that performance expectancy, effort expectancy, and social influence positively influence behavioral intention to use, while facilitating conditions positively influence actual use behavior. We have modified the research model by incorporating an additional factor, perceived risk. This factor is expected to negatively impact the intention to use an online platform for freight forwarding services. This section details the hypotheses developed based on these relationships and how they influence the intention to use the platform.

2.2.1. Performance Expectancy (PE)

According to [15], performance expectancy (PE) refers to the belief that a specific technology will improve efficiency and effectiveness of tasks [21]. In this context, PE focuses on users' perceptions of convenience, service-tracking enhancements, and quality of service offered by an online platform for freight forwarding services [20,21,43]. While PE might not capture all aspects of perceived value (e.g., cost saving), it remains a critical factor influencing user adoption [17]. Previous research supports a positive relationship between perceived usefulness (similar to PE) and intention to use technological systems [2,32,44]. Therefore, we hypothesized that a higher perceived PE (convenience, service tracking, quality of service) will lead to a stronger intention to use an online platform for freight forwarding services. This hypothesis will be further tested empirically in this study.

H1: *Performance expectancy has a positive influence on the intention of Thai firms to use an online platform for freight forwarding services.*

2.2.2. Effort Expectancy (EE)

Effort expectancy (EE) reflects the perceived difficulty in using a technology. Users who find a technology difficult to learn or use may become discouraged and discontinue use [15]. In the context of online freight forwarding platforms, EE refers to the perceived ease of using the platform's interface, navigating functionalities, and completing tasks like booking shipments or tracking goods. Previous research has shown that perceived ease of use (similar to EE) positively impacts the intention to use technological systems [31,45]. Studies by Alwahaishi and Snášel (2013) [46,47] and Sarfaraz (2017) [48] also confirm the significant influence of EE on users' intention to adopt ICT technologies. Therefore, the following hypothesis explores the relationship between EE and intention to use an online platform for freight forwarding services.

H2: *Effort expectancy has a significant positive influence on the intention of Thai firms to use an online platform for freight forwarding services.*

2.2.3. Social Influence (SI)

Social influence (SI) reflects the effect of referent opinions from important others on individual user behavior [49,50]. In the context of Thai firms, SI can be shaped by recommendations from industry peers, logistics associations, or trusted business partners [2,3]. According to SI theory, users are more likely to adopt a technology if those they respect recommend it [15,51]. Therefore, we proposed the following hypothesis:

H3: *Social influence has a positive influence on the intention of Thai firms to use an online platform for freight forwarding services.*

2.2.4. Perceived Risk (PR)

One critical factor not explicitly addressed in the original UTAUT model is perceived risk (PR). In freight forwarding, the stakes are high, with substantial financial and operational implications tied to logistics efficiency and reliability. PR directly influences trust, which is crucial for users when adopting new technologies in this sector [52]. Additionally, the logistics industry frequently handles sensitive data, such as shipment details, customer information, and financial transactions [53]. The PR associated with data security and privacy can significantly affect companies' willingness to adopt online freight forwarding platforms. Therefore, PR plays a vital role in adoption decisions within this domain. PR refers to the uncertainties and potential negative outcomes a firm perceives from adopting a new system or service [34,54–56].

In the context of online platforms, common risk concerns include data security and privacy breaches, system reliability and uptime, integration and interoperability issues, and loss of control over critical business processes [34,35,54,56]. Several empirical studies have demonstrated that PR can negatively impact the adoption intentions of various technologies, such as e-procurement [28], enterprise resource planning (ERP) [32], and blockchain in supply chains [24,25]. These findings suggest that including PR as an additional factor in the UTAUT model could provide a more comprehensive understanding of the factors influencing the adoption of online freight forwarding platforms. Therefore, the fourth hypothesis was proposed as follows:

H4: *Perceived risk has a negative influence on the intention of Thai firms to use an online platform for freight forwarding services.*

2.2.5. Facilitating Conditions (FCs)

Facilitating conditions (FCs) refer to the resources and knowledge that users need to effectively use a technology [15]. They refer to the belief that there is an organizational and technical infrastructure in place to support the system [57]. If users lack these resources and knowledge, they may not continue using the technology [49]. Alwahaishi and Snášel (2013) [47] studied the factors affecting the acceptance and use of mobile internet as an ICT application in a consumer context and found strong support for FCs based on empirical data. Similarly, FCs have been found to influence consumer adoption of cloud computing services in Germany [29], blockchain adoption in logistics companies in Vietnam [26], online shopping in Bangladesh [58], and E-payment in Yemen [21]. Additionally, studies have shown a significant relationship between FCs and the actual use of internet banking [44]. Most research confirms that intention to use positively impact the actual use of technologies, such as adopting big data in supply chain management [31], and material procurement in construction companies in India [28]. Based on these findings, two hypotheses regarding the FC factor were formulated as follows:

H5: *Facilitating conditions have a positive influence on the intention of Thai firms to use an online platform for freight forwarding services.*

H6: *Facilitating conditions have a positive influence on the actual use of an online platform for freight forwarding services by Thai firms.*

2.2.6. Intention to Use (IU) and Actual Use (AU)

In the traditional UTAUT model, intention to use (IU) is widely recognized as a strong predictor of actual use (AU). Given its close alignment with behavior, many studies incorporating intentions into their frameworks focus on measuring behavioral adoption intentions. Individuals tend to be more engaged when their intention towards using a

technology is positive, significantly impacting usage behavior with the intention to continue use, indicating a proactive effort and planning to use the technology. Previous studies have shown a positive influence of IU on AU, such as in the use of ICT in tourism [43] and E-government services [59]. Based on these observations, the seventh hypothesis was formulated as follows:

H7: *Intention to use has a positive influence on the actual use of an online platform for freight forwarding services by Thai firms.*

2.2.7. Moderators

Additionally, this study aims to explore how firm size and user generation moderate the relationship between the main factors and the intention to use an online platform for freight forwarding services. Existing studies indicate that firm size may have specific characteristics that affect the adoption of information technology, particularly in small and medium-sized enterprises [9,11,37,60–63]. Furthermore, we refine the traditional UTAUT model by adjusting the respondents' age to consider generation or age group, as this factor may influence the intention to use information systems. Therefore, the following hypotheses were developed to be tested with empirical data in the context of Thailand. Eight sub-hypotheses were proposed to test the moderating effect of firm size (H8a–d) and user generation (H9a–d) on the relationships between intention to use (IU) and the proposed UTAUT predictors: performance expectancy (PE), effort expectancy (EE), social influence (SI), and perceived risk (PR).

H8a: *The impact of performance expectancy on intention to use is moderated by firm size.*

H8b: *The impact of effort expectancy on intention to use is moderated by firm size.*

H8c: *The impact of social influence on intention to use is moderated by firm size.*

H8d: *The impact of perceived risk on intention to use is moderated by firm size.*

H9a: *The impact of performance expectancy on intention to use is moderated by user generation.*

H9b: *The impact of effort expectancy on intention to use is moderated by user generation.*

H9c: *The impact of social influence on intention to use is moderated by user generation.*

H9d: *The impact of perceived risk on intention to use is moderated by user generation.*

2.3. Proposed Structural Model

Based on the literature review, this study proposes a modified UTAUT-based model to analyze the factors influencing the intention to adopt an online platform for freight forwarding services by Thai firms. This model expands the UTAUT framework by integrating perceived risk as an additional significant inhibitor of adoption intention, alongside the four primary predictors: performance expectancy, effort expectancy, social influence, and facilitating conditions.

Furthermore, the model includes two moderating variables, firm size and user generation, to explore their potential impacts on the relationships between the predictors and the intention to adopt online platforms for freight forwarding services. Firm size is suggested as a moderator based on previous studies [30,32], which indicates that larger firms may have distinct considerations and capabilities regarding technology adoption compared to small and medium-sized enterprises (SMEs) [9,60]. User generation is also incorporated as a moderator based on UTAUT's proposition that younger individuals may exhibit greater openness to new technologies than older generations. The proposed modified UTAUT-based model for this study is illustrated in Figure 1.

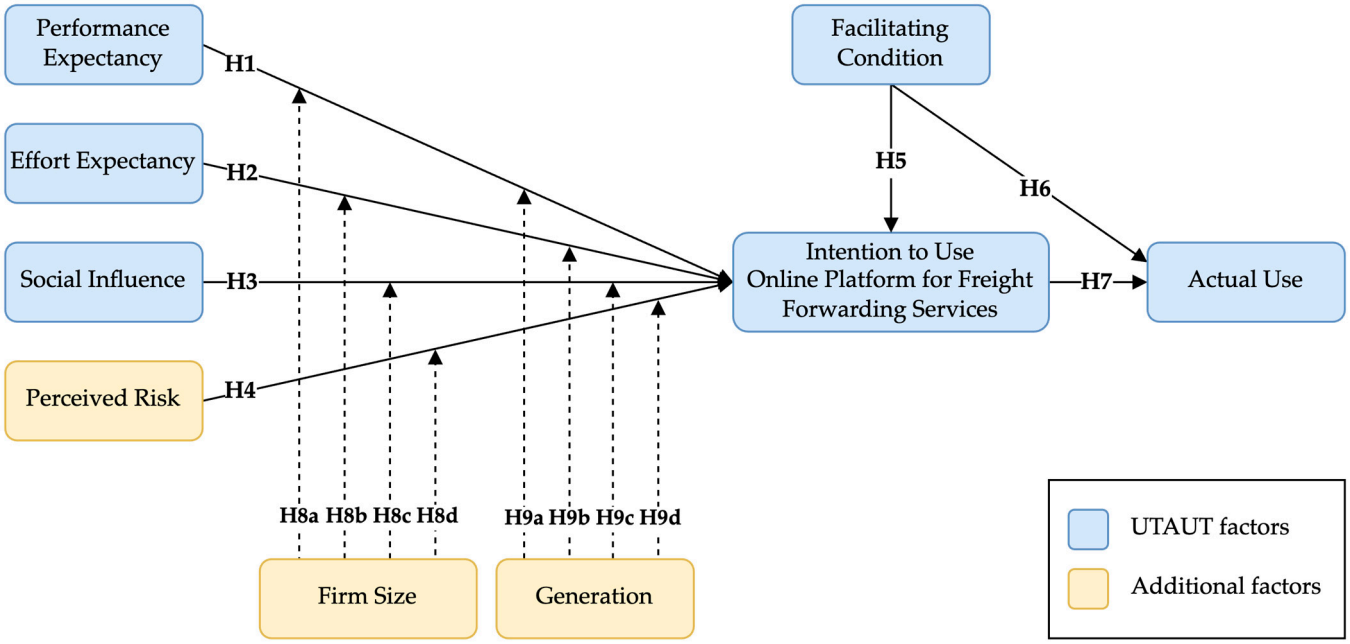

Figure 1. The proposed modified UTAUT-based model.

3. Methodology

3.1. Participants

This study utilized a quantitative, cross-sectional survey design to collect data for testing the hypothesized relationships in the research model. The target population comprised employees in Thai firms responsible for making decisions or managing processes related to the use of freight forwarding services for their organizations' cross-border shipping needs. This included roles such as supply chain managers, logistics managers, import/export managers, and shipping executives.

To recruit participants, a purposive sampling approach was employed through two main channels. Firstly, an industry database maintained by the Thai International Freight Forwarders Association (TIFFA) was used to identify potential respondents based on their job titles and company profiles. To mitigate bias, the population within this group was proportionally divided into strata based on the key demographic variable of firm size. Participants from each stratum were then selected using sampling techniques to reduce selection bias. Secondly, the customer databases of five leading freight forwarders operating in Thailand were utilized to reach out to key decision-makers in their client organizations. The participating forwarders were selected based on their market share, service offerings, and willingness to support the research.

The sample size was determined to be 400, which is widely recognized and applied across various research fields for its statistical accuracy of ±5% and is often considered the most cost-effective sample size [64,65]. According to the literature [66], a minimum sample size of 200 is typically required for robust SEM analysis.

3.2. Measures and Questionnaire

This study employed a survey questionnaire, which was presented in the Thai language for accessibility and structured into two main sections. The first section gathered demographic information and usage experience of participants, including their position, age group, average use of freight forwarding shipment services, and the size of their company. The second part consisted of Likert-scale questions concerning factors influencing the intention to adopt an online platform for freight forwarding services. Respondents rated their opinions using a five-point Likert scale, ranging from "strongly agree" (5) to "strongly disagree" (1).

Before distribution, the questionnaire underwent content validity testing using the Index Objective Congruence (IOC) to ensure the accuracy of its content [67]. Three experts from selected freight forwarding companies reviewed the questionnaire. Based on their feedback, minor modifications were made to improve the wording and flow of the questions.

To assess the questionnaire's reliability, it was pretested with a sample of 30 logistics professionals to ensure clarity, comprehensiveness, and reliability. Cronbach's alpha coefficient (α) was used to measure the questionnaire's reliability, with a value greater than 0.7 indicating good reliability [68].

The final survey instrument was implemented on an online survey platform. Data collection took place from February to April 2024, during which rigorous quality checks were implemented to ensure the validity of responses. Survey forms with suspicious response styles or incomplete answers were excluded from the analysis. The measurement is the questionnaire used in this research is presented in Table 2.

Table 2. Measurement items.

Constructs	Items	Source
Performance Expectancy (PE)	PE1: The use of an online platform for freight forwarding services will enhance our logistics performance compared to paper-based processes. PE2: Utilizing an online platform of freight forwarding services enables us to compete our logistics activities more rapidly. PE3: The use of an online platform for freight forwarding services improves the quality of our logistics activities. PE4: Using an online platform for freight forwarding services simplifies our logistics activities. PE5: Utilizing an online platform of freight forwarding services enhances our efficiency in logistics activities.	[3,15,69,70]
Effort Expectancy (EE)	EE1: Interacting with an online platform for freight forwarding services would be clear and understandable. EE2: It would be easy for us to become proficient at using an online platform for freight forwarding services in our business. EE3: Learning to operate an online platform for freight forwarding services is straightforward for our staffs. EE4: An online platform for freight forwarding services is compatible with our company.	[15,69]
Social Influence (SI)	SI1: The top management of our company believes that using an online platform for freight forwarding services is essential for digital transformation. SI2: Staff involved in freight booking believe that using an online platform for freight forwarding services should rely more on digitized documents. SI3: Using an online platform for freight forwarding services enhances commercial satisfaction for supply chain partners/customers.	[3,15,69]
Perceived Risk (PR)	PR1: Utilizing digital or paperless documents through an online platform for freight forwarding services may result in the potential loss of important information of our company. PR2: Using an online platform for freight forwarding services may lead to a possible loss of time for our staffs compared to traditional processes. PR3: Using an online platform for freight forwarding services may result in a potential loss of performance accuracy. PR4: Implementing an online platform for freight forwarding services may incur the possible cost of training staff. PR5: Using an online platform for freight forwarding services may lead to a potential loss of cooperation between our company and the freight forwarder.	[34,35,55]

Table 2. *Cont.*

Constructs	Items	Source
Facilitating Conditions (FCs)	FC1: Our company possesses the necessary information technology facilities to effectively utilize an online platform for freight forwarding services. FC2: Our company has the requisite knowledge to effectively utilize an online platform for freight forwarding services. FC3: There is technical support available online to assist with any difficulties encountered in using an online platform for freight forwarding services.	[15,69]
Intention to Use (IU)	IU1: I believe our company would adopt an online platform for freight forwarding services if it were available in the market. IU2: Our company is seriously considering the adoption of an online platform for freight forwarding services in the near future. IU3: Our company has a plan to utilize an online platform for freight forwarding services as a part of our digital transformation strategy.	[15,71]
Actual Use (AU)	AU1: Our company is prepared to utilize an online platform for freight forwarding services as a significant step towards digital transformation. AU2: Our company uses an online platform for freight forwarding services to partially or fully replace traditional freight forwarding services. AU3: Our company use an online platform for freight forwarding services to manage logistics.	[15,32]

3.3. Data Analysis: Structural Equation Modeling (SEM)

In this study, we followed a two-step approach to structural equation modeling (SEM) analysis, as recommended by [72]. Firstly, we conducted confirmatory factor analysis (CFA) to assess the reliability and validity of the measurement scales used in our proposed model. This step allowed us to evaluate the adequacy of the measurement model by examining goodness-of-fit criteria, including the minimum discrepancy divided by degrees of freedom (CMIN/df), the Comparative Fit Index (CFI), Tucker–Lewis Index (TLI), Root Mean Square Error of Approximation (RMSEA), and Standardized Root Mean Square Residual (SRMR) [73].

After validating the measurement model, we estimated the structural model using maximum likelihood estimation. This step involved examining path coefficients to determine the strength and significance of relationships between latent variables in our model. We also evaluated the overall fit of the structural model using fit indices.

Data analysis was performed using the IBM SPSS and AMOS 26.0 statistical packages. SPSS was utilized for data preparation and descriptive statistics, whereas AMOS 26.0 was employed for CFA and SEM analysis. This study included a sample of 400 respondents who are employees in Thai firms responsible for decisions or processes related to the use of freight forwarding services. The two-step SEM analysis provided valuable insights into the concurrent influences among the factors in our conceptual model, helping us to understand the complex relationships between variables and their implications for theory and practice.

4. Results

4.1. Demographic Structure of Respondents

The main part of this research study involved distributing an online questionnaire. A total of 400 complete responses were collected, with all respondents having experience using freight forwarding services in the past three months. The majority of the respondents held positions as import or export managers (43.3%) and logistics managers (35.5%). In terms of firm size, 45.3% were from small enterprises, while 35.5% were from medium-sized enterprises. Regarding generational categories (age group), the majority were Gen Y or millennials (30–43 years old), accounting for 65.5% of all respondents. Table 3 presents key aspects of the demographic structure of the respondents.

Table 3. Analysis of the demographic characteristics.

Categories	Dimensions	Frequency (*n*)	Percentage (%)
Position	Chief/managing director	29	7.3%
	Import/export manager	173	43.3%
	Logistics manager	142	35.5%
	Other management levels or equivalent	56	14.0%
Generation	Gen X (over 43 years old)	61	15.3%
	Gen Y or Millennials (30–43 years old)	262	65.5%
	Gen Z (29 years old or less)	77	19.3%
Average usage shipment	Less than 5 TEUs a month	100	25.0%
	5–20 TEUs a month	140	35.0%
	21–50 TEUs a month	84	21.0%
	More than 50 TEUs a month	76	19.0%
Firm size	Small (less than THB 50 million/year)	181	45.3%
	Medium (THB 51–300 million/year)	142	35.5%
	Large (more than THB 300 million/year)	77	19.3%
Use of freight forwarding service (past 3 months)	Yes	400	100.0%
	No	0	0%
	Total	400	100%

4.2. Assessment of the Measurement Model

Before analyzing the measurement model, descriptive statistics were computed for the 28 observed variables related to the acceptance of adopting an online platform for freight forwarding services in Thai firms. Each statement in the questionnaire, detailed in Table 2, was rated on a 5-point Likert scale ranging from "strongly agree" (5) to "strongly disagree" (1). The survey, conducted with 400 respondents, indicated that the degree of agreement for each observation item was higher than the moderate value or scale "3", except for the item measuring "Perceived Risk (PR)". This particular variable highlighted barriers or negative outcomes in the adoption of an online platform for freight forwarding services, where a lower score indicated a more positive outlook. The scale was recoded such that "strongly disagree" corresponded to a score of 5 and "strongly agree" to 1.

In preparation for structural equation model (SEM) or confirmatory factor analysis (CFA), assessing the normality of the data is crucial [74]. Typically, multivariate normality is tested, and for sample sizes larger than 300, normality can be evaluated using histograms and by examining the absolute values of skewness and kurtosis. In SPSS, these values should ideally approximate zero in a normal distribution [75,76]. For this study, skewness and kurtosis values within the range of ± 1.96 indicate normal distribution [77]. Detailed descriptive statistics of the variables and results of normality testing are presented in Table 4.

To confirm the reliability and validity of the structural model, individual questionnaire responses were analyzed. Factor loading (FL) values were calculated for each question to determine the Average Variance Extracted (AVE) and Construct Reliability (CR) values. The results are presented in Table 5, where it can be observed that all FL values exceed 0.5, all AVE values exceed 0.5, and all CR values exceed 0.6 (with CR values for all variables exceed 0.80) [78]. Cronbach's alpha values presented in Table 5 meet the minimum acceptable value of 0.70 for all the variables [68]. Therefore, the internal consistency and reliability of the scales used in this study are considered satisfactory.

Subsequently, each item within every factor underwent rigorous evaluation using reduction techniques to confirm its alignment with the intended constructs. Confirmatory factor analysis (CFA) is a statistical method essential for examining relationships among latent variables which is integral to SEM methodology and crucial for validating measurement models in path or structural analyses. CFA estimates latent variables based on the correlated variation within the dataset. Before assessing the structural model in SEM,

researchers ensure that the measured variables accurately reflect the intended constructs or factors.

Table 4. Descriptive statistics of variables (n = 400).

Constructs	Items	Mean	Standard Deviation	Skewness	Kurtosis
Performance Expectancy (PE)	PE1	3.96	0.678	−0.291	0.115
	PE2	3.97	0.705	−0.299	−0.061
	PE3	3.96	0.778	−0.477	−0.037
	PE4	3.95	0.810	−0.452	−0.256
	PE5	3.99	0.771	−0.317	−0.461
Effort Expectancy (EE)	EE1	4.06	0.786	−0.697	0.328
	EE2	4.09	0.701	−0.298	−0.362
	EE3	4.08	0.762	−0.742	0.607
	EE4	4.03	0.665	−0.088	−0.565
Social Influence (SI)	SI1	4.04	0.650	−0.477	0.852
	SI2	3.99	0.761	−0.357	−0.109
	SI3	4.03	0.791	−0.746	0.482
Perceived Risk (PR)	PR1	3.61	0.851	−0.727	1.004
	PR2	3.74	0.819	−0.080	−0.616
	PR3	3.99	0.883	−0.415	−0.739
	PR4	3.70	0.716	−0.379	0.076
	PR5	3.64	0.733	−0.273	−0.124
Facilitating Condition (FC)	FC1	3.99	0.629	−0.296	0.496
	FC2	4.06	0.669	−0.366	0.251
	FC3	3.96	0.747	−0.629	0.526
Intention to Use (IU)	IU1	4.04	0.582	−0.156	0.529
	IU2	4.05	0.694	−0.297	−0.184
	IU3	4.10	0.623	−0.198	.037
Actual Use (AU)	AU1	3.75	0.589	−0.691	0.927
	AU2	3.75	0.588	−0.914	1.257
	AU3	3.73	0.633	−1.013	1.217

The structural equation model (SEM) in this study demonstrates a strong fit across several key goodness-of-fit criteria. The CMIN/df ratio, which measures the discrepancy between the model and observed data adjusted for degrees of freedom, is reported at 3.306, indicating a good fit, as values below 5 are generally considered acceptable. The Root Mean Square Error of Approximation (RMSEA) stands impressively low, at 0.044, well below the threshold of 0.08, suggesting a very close fit of the model to the data. The Standardized Root Mean Square Residual (SRMR) is also low, at 0.032, indicating excellent fit where values closer to zero denote better model fit. The Non-normed Fit Index (NNFI) or Tucker–Lewis Index (TLI) is reported at 0.779, slightly below the preferred threshold of 0.90 but still acceptable, suggesting the model provides a reasonable fit relative to a baseline model. Similarly, the Comparative Fit Index (CFI), at 0.833, though also slightly below 0.90, indicates a good overall fit of the model to the data. These findings collectively indicate that the SEM in this study exhibits a robust fit according to most criteria, suggesting it accurately represents the relationships among the variables under investigation. However, the slightly lower values of NNFI and CFI suggest that there may still be room for improvement, such as refining the model specification or addressing potential measurement issues. The results, alongside the cut-off values denoting a good fit, are presented in Table 6.

Table 5. Determining the reliability and validity of the model.

Constructs	Items	FL	AVE	CR	Cronbach's α
Performance Expectancy (PE)	PE1	0.789	0.651	0.903	0.863
	PE2	0.836			
	PE3	0.850			
	PE4	0.785			
	PE5	0.771			
Effort Expectancy (EE)	EE1	0.867	0.608	0.859	0.782
	EE2	0.790			
	EE3	0.844			
	EE4	0.585			
Social Influence (SI)	SI1	0.792	0.647	0.845	0.723
	SI2	0.749			
	SI3	0.867			
Perceived Risk (PR)	PR1	0.851	0.679	0.914	0.877
	PR2	0.770			
	PR3	0.779			
	PR4	0.875			
	PR5	0.841			
Facilitating Condition (FC)	FC1	0.785	0.639	0.841	0.711
	FC2	0.855			
	FC3	0.754			
Intention to Use (IU)	IU1	0.810	0.721	0.886	0.801
	IU2	0.819			
	IU3	0.915			
Actual Use (AU)	AU1	0.789	0.714	0.882	0.799
	AU2	0.866			
	AU3	0.877			

Table 6. CFA statistics of model fit.

Goodness-of-Fit Indexes	Result Model	Cut-Off for Good Fit	Source
CMIN/df	3.306	Good $\leq$ 3 and acceptable < 5	[79,80]
RMSEA	0.044	Excellence < 0.01, good > 0.01–0.05, medium > 0.05 to 0.08, and poor > 0.1	[81–84]
SRMR	0.032	<0.08	[83]
NNFI or TLI	0.779	0 = poor fit Close to 1 = very good fit	[73,85]
CFI	0.833	0 = poor fit Close to 1 = very good fit	[83,86]

4.3. Structural Model and Hypotheses Testing

This step involved testing the structural model to elucidate the relationships between constructs in the research model. Path analysis, a common form of SEM analysis, was employed to investigate the direct impact and causal relationships among variables. The significance of each hypothesized structural path was assessed using standardized path coefficients (β) and *p*-values.

Table 7 displays the path values, critical ratio (C.R.), standard error (S.E.), and significance level (*p*-value). In the analysis, the absolute value of the standardized path coefficient (β) indicates the magnitude of influence, with positive values indicating a positive influence and negative values indicating a negative influence. The critical ratio (C.R.) for the independent variable is a *z* statistic, equal to the ration of the parameter estimate to its standard deviation. The *p*-value represents the probability of the statistical test of C.R.

Table 7. Results of coefficient path analysis.

Hypothesis	Path		β	S.E.	C.R.	Result
H1	Performance Expectancy (PE)	→ Intention to Use (IU)	0.478 ***	0.078	3.925	Supported
H2	Effort Expectancy (EE)	→ Intention to Use (IU)	0.168 *	0.034	2.442	Supported
H3	Social Influence (SI)	→ Intention to Use (IU)	0.262 ***	0.065	3.321	Supported
H4	Perceived Risk (PR)	→ Intention to Use (IU)	−0.211 ***	0.022	−4.451	Supported
H5	Facilitating Conditions (FCs)	→ Intention to Use (IU)	0.458 ***	0.073	3.611	Supported
H6	Facilitating Conditions (FCs)	→ Actual Use (AU)	0.442 ***	0.059	4.579	Supported
H7	Intention to Use (IU)	→ Actual Use (AU)	0.663 ***	0.104	6.753	Supported

Note: *** $p < 0.001$; * $p < 0.05$.

Six paths were found to be significant at $p < 0.001$, while one path was significant at $p < 0.05$. All paths were considered significant, as the C.R. exceeded 1.96 and the p-value was less than 0.05. The notation "***" and "*" denotes p-values less than 0.001 and 0.05, respectively.

The analysis of influencing factors revealed that hypotheses H1–H7 are supported. Perceived risk (PR) was found to have a significant negative impact on the intention to use (IU) ($\beta = -0.211$, $p < 0.001$), supporting the fourth hypothesis (H4). This finding contradicts various existing literature on the acceptance of online platforms [55,56,87], which suggests that PR reduces the willingness to use an online platform for freight forwarding services. Organizations are aware of potential loss of time and important information in services, as well as of the capabilities of their staff.

Additionally, the effect of performance expectancy (PE) on the intention to use (IU) was found to be positive and significant ($\beta = 0.478$, $p < 0.001$), supporting the first hypothesis (H1). Firms intending to use an online platform for freight forwarding services believe that the platform will simplify and enhance efficiency in their activities compared to paper-based processes. Similarly, the result indicates that effort expectancy (EE) was positively and significantly related to the IU ($\beta = 0.168$, $p < 0.05$), confirming the second hypothesis (H2). This result suggests that firms are making efforts to understand and try new information systems for their business.

Furthermore, the third hypothesis (H3) revealed that social influence (SI) has a positive and significant impact on the intention to use (IU) ($\beta = 0.262$, $p < 0.001$). Digital transformation can enhance satisfaction among supply chain partners, thereby supporting H3.

Moreover, the fifth hypothesis (H5) suggested that facilitating conditions (FCs) have a positively significant effect on the intention to use (IU) ($\beta = 0.458$, $p < 0.001$), thus H5 was supported. Similarly, FCs also positively influenced actual use (AU), confirming the sixth hypothesis (H6) ($\beta = 0.442$, $p < 0.001$). This indicates that support from the company, including managerial support to enhance knowledge for digital transformation and information technology facilities, promotes the use of an online platform in their activities.

Finally, the intention to use (IU) was found to have a positively significant effect on actual use (AU) ($\beta = 0.663$, $p < 0.001$), supporting H7. The staff of the firm's intention to use an online platform for freight forwarding services leads to actual use of the platform and prompts digital transformation in their logistics processes. The structural model and path coefficients is illustrated in Figure 2.

4.4. Analysis of Moderating Effects

The moderating effects of firm size and user generation on the structural model were examined using multigroup analysis. Hypotheses five and six predicted that organization size and generation would moderate the effect of variables (performance expectancy (PE), effort expectancy (EE), social influence (SI), and perceived risk (PR)) on the intention to use of an online platform for freight forwarding services, respectively. Each moderating variable was split into two groups and analyzed using the critical ratios approach [73].

For the first moderating variable, "firm size," respondents were divided into small and medium-sized enterprises (SMEs) ($n = 323$) and large-sized enterprises ($n = 77$) for

examination. For the second moderating variable, "generation," respondents were split into Generation X (age over 43 years old, n = 61) and Generation Y or Millennials and Generation Z (age less than 43, n = 339) for comparison based on generation context.

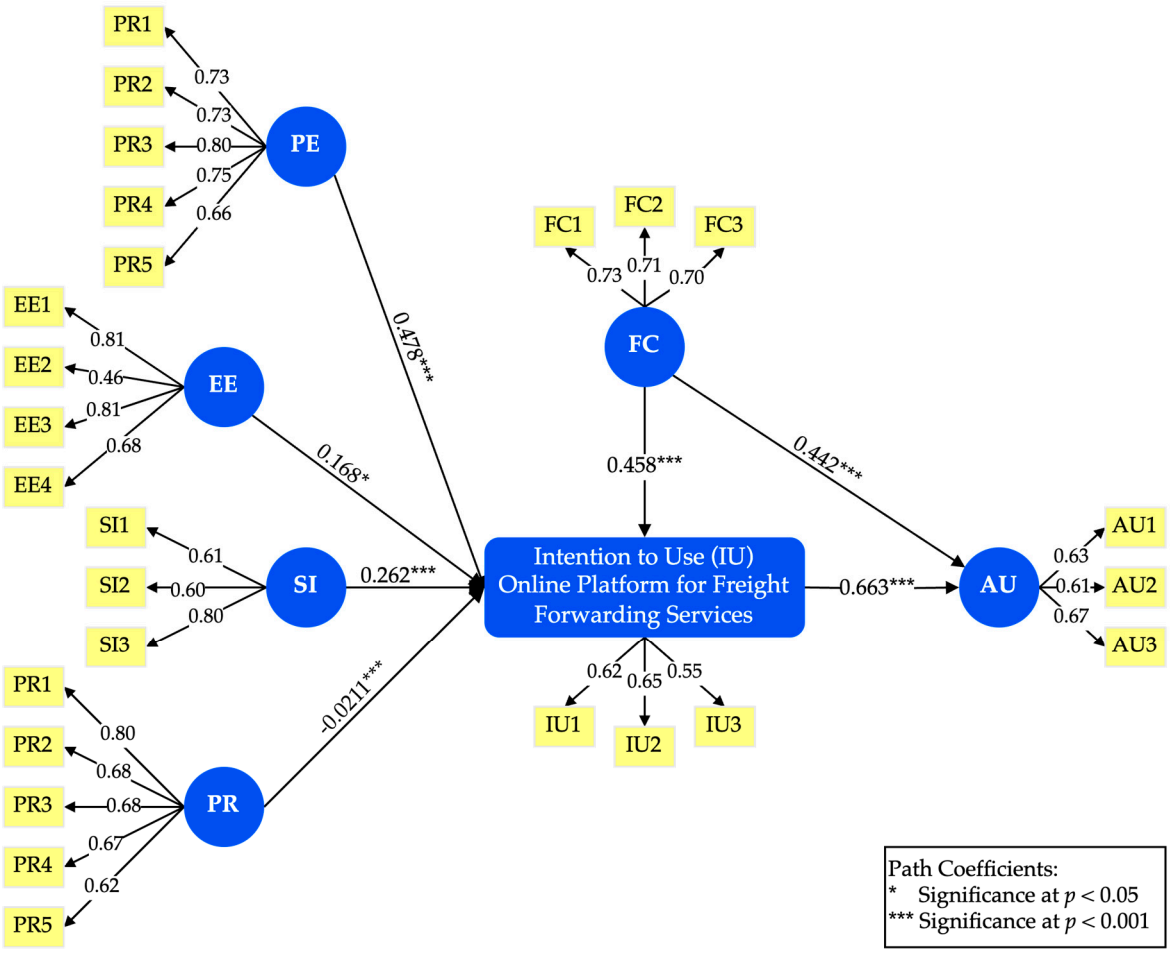

Figure 2. Structural model and path coefficients.

The effects of the two moderating variables are presented in Table 8. Estimates are unstandardized coefficients. z-scores indicate the significance of difference between path coefficients. The symbols ***, **, and * indicate significance at $p < 0.001$, 0.01, and 0.05, respectively.

Table 8 presents the results, with z-scores indicating the significance of the difference between path coefficients. The analysis reveals that social influence (SI) has a significant impact on the intention to use (IU) in both firm sizes, with the effect being significantly stronger among large organizations. Therefore, hypothesis H5c was confirmed with a z-score greater than 1.96 (z-score = 2.187, $p < 0.01$). However, the other factors investigated, including performance expectancy (PE), effort expectancy (EE), and perceived risk (PR), showed no significant differences between SMEs and large enterprises, as indicated by z-scores less than 1.96. This means hypotheses H8a, H8b, and H8d were rejected.

Regarding user generation or age group as a moderating variable, Generation Y and Generation Z were regrouped into the same category due to their similar information technology skills and knowledge compared to previous generations. The results indicate that there were no significant differences in any of the constructs between Generation X and Generation Y or Z respondents. Consequently, all six hypotheses, H9a–H9d, were rejected, as the z-scores were less than 1.96. In other words, the effect of PE, EE, SI, and PR on adoption intention is not moderated by user generation.

Table 8. Effects of moderating variables.

Firm Size			**SME Estimate (n = 323)**	**Large Enterprise Estimate (n = 77)**	***z*-Score**	**Moderation**
H8a	Performance Expectancy (PE)	→ Intention to Use (IU)	0.572 ***	0.179	−1.412	No
H8b	Effort Expectancy (EE)	→ Intention to Use (IU)	0.154 *	0.242	0.314	No
H8c	Social Influence (SI)	→ Intention to Use (IU)	0.201 *	0.785 ***	2.187 **	Yes
H8d	Perceived Risk (PR)	→ Intention to Use (IU)	−0.234 ***	−0.053	1.623	No
Generation			**Generation X Estimate (n = 61)**	**Generation Y and Z Estimate (n = 339)**	***z*-Score**	**Moderation**
H9a	Performance Expectancy (PE)	→ Intention to Use (IU)	0.810	0.364 **	−0.617	No
H9b	Effort Expectancy (EE)	→ Intention to Use (IU)	−0.777	0.198 **	0.522	No
H9c	Social Influence (SI)	→ Intention to Use (IU)	1.701	0.177 *	−0.732	No
H9d	Perceived Risk (PR)	→ Intention to Use (IU)	0.518	−0.252 ***	−0.805	No

Note: *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$.

5. Discussion and Implications

5.1. Discussion of Results

This study aimed to analyze the factors influencing the adoption an online platform for freight forwarding services, leading to actual use behavior in Thailand. The main variables observed were performance expectancy (PE), effort expectancy (EE), social influence (SI), facilitating condition (FC), and perceived risk (PR), based on the modified UTAUT model. A survey was conducted with 400 participants from Thai firms that have experience using freight forwarding services.

Out of the fifteen hypotheses tested, eight were accepted (H1–H7), while the rest were rejected (H8a, H8b, H8d, H9a–H9d). H8c was accepted based on the moderating effect tests for firm size.

The findings of this study confirm the significant positive impact of performance expectancy (PE) on the intention to use an online platform for freight forwarding services in Thailand. This result aligns with [15], suggesting that PE influences continuance intention. Additionally, this study is consistent with previous research on the use of new technologies in logistics activities [41,42,47,88], indicating that performance expectancy, effort expectancy, and risk perception significantly influence users' intention to use new technologies. This implies that a higher perceived degree of PE by users leads to a greater intention to use an online platform.

Effort expectancy (EE) was also found to significantly affect the intention to use an online platform for freight forwarding service positively. This indicates that a high perceived degree of EE by user leads to a greater intention to use the platform. As explained by [15], EE reflects the perceived difficulty in using a new technology. The results of this study are consistent with previous research showing that perceived ease of use (similar to EE) affects user satisfaction [42,55] and continued use [42], as well as intention to use [47].

Social influence (SI) was found to have a significant positive effect on the intention to use an online platform for freight forwarding services. This suggests that a higher perceived degree of SI among users leads to a greater intention to use the technology. SI reflects the effect of referent opinion on individual user behavior [89]. These results are consistent with previous studies [31,90], which also found that SI significantly influences the intention to continue using online platforms or information technologies for related logistics and supply chain management activities. Additionally, Lee and Song [56] found that performance expectancy and social influence positively influence behavioral intention, a finding that aligns with the results of this study.

The results of this study confirmed that perceived risk (PR) significantly influenced the intention to use an online platform for freight forwarding services, with a negative impact. This implies that a higher perception of associated risks among users leads to a lower

level of intention to use the technology. Digital risk represents unexpected breakdowns, contagions, and interruptions between the company and business partners in the supply chain [91]. Similarly, Lee and Song [56] studied the effects of trust and PR on user adoption of a new technology service and found that trust and PR are direct antecedents of intention to use, which is consistent with the findings of this study. Abrahão et al. [92] investigated the intention to use ICT services based on the UTAUT and found that 76% of behavioral intentions were explained by performance expectancy, effort expectancy, social influence, and perceived risk, which is also supported by the findings of this study.

The results confirmed that facilitating conditions (FCs) significantly affected the intention to use and actual use of an online platform for freight forwarding services in Thai firms, with a positive impact. This indicates that a higher favorability of FCs as perceived by users leads to a higher level of adoption intention toward the technology. FCs refer to users having the necessary resources and knowledge to use the technology, as explained in [15]. In an organizational context, FCs are defined as one's belief that an organizational and technical infrastructure exists to support the system [57,88]. Similarly, Alwahaishi and Snášel [46] empirically investigated how FCs influence the acceptance and use of ICT applications. In logistics companies, FCs positively influence the behavioral intention to use blockchain [26]. Alalwan et al. [44] found similar results supporting that there is a statistically significant relationship between facilitating conditions and the actual use of online financial services, which is also similar to some of the facilities needed to use e-services. For SMEs in European nations, digitalization adoption is also influenced by FCs [93], as supported by this study regarding our participants' demographic (Table 3), where 80.8% of respondents are SMEs.

In the proposed modified UTAUT model, the impact of the main factors was not moderated by firm size and generation, except for social influence (SI). Firm size was found to moderate SI, suggesting that the relationship between SI and intention to use was significant for both SMEs and particularly for large-sized enterprises. Large enterprises often rely on high-potential emerging technologies or technological innovations to enhance their competitiveness, outperform competitors [94,95], and ensure business sustainability [96,97].

The results confirmed that the intention to use significantly influenced the actual use in the case of applying an online platform for freight forwarding services in Thailand. This finding is consistent with several other studies [59,98,99].

5.2. Practical Implications

In response to the findings suggesting practical implications for freight forwarding companies, the action plan focuses on several key strategies aimed at improving the adoption of online platforms. The first strategy emphasizes highlighting the performance benefits of these platforms, such as enhanced logistics efficiency and reduced reliance on paper-based processes. To achieve this, the marketing team will develop comprehensive marketing materials, including videos and case studies. Concurrently, the customer success team will organize workshops and webinars to demonstrate firsthand how these platforms can optimize logistics operations.

The second strategy centers on ensuring robust IT support and infrastructure. This involves establishing a dedicated IT support team to provide immediate assistance to customers encountering platform-related issues. Additionally, the IT department will focus on developing and reinforcing the necessary IT infrastructure to ensure seamless platform functionality, particularly catering to the needs of SMEs lacking extensive IT resources.

A crucial aspect of the plan involves leveraging social influence to foster platform adoption. This strategy begins with identifying and partnering with prominent freight forwarding firms willing to serve as early adopters and demonstrate successful platform implementations. This initiative aims to create positive role models within the industry. Moreover, the marketing team will collaborate to document and promote these success stories through various channels, thereby building confidence and interest among potential users.

Addressing perceived risks associated with online platforms constitutes the fourth strategy. Immediate measures include implementing stringent data security protocols to safeguard customer information. Concurrently, the customer success team will actively collect and disseminate positive testimonials from satisfied customers, fostering trust and mitigating apprehensions surrounding platform usage. Furthermore, enhancing customer support services will ensure prompt resolution of any concerns, further bolstering customer confidence in the platform's reliability.

Lastly, streamlining the user experience stands as the fifth strategy to facilitate platform adoption. This involves refining the platform's user interface through rigorous user testing and iterative design improvements, overseen by the UX/UI design team. Integrating artificial intelligence (AI) tools will further enhance user interaction by providing instant and continuous support. Simultaneously, the training department will develop comprehensive user tutorials and guides within two months to streamline onboarding processes and minimize the learning curve for new users.

In conclusion, by adhering to this structured action plan, freight forwarding companies can effectively implement the identified practical implications. This holistic approach not only addresses performance benefits and IT infrastructure requirements but also harnesses social influence, mitigates perceived risks, and enhances user experience. Through these concerted efforts, companies can achieve heightened efficiency, customer satisfaction, and competitive advantage in the marketplace.

5.3. Theoretical Implications

Based on the comprehensive discussion and practical implications derived from this study on factors influencing the adoption of online platforms for freight forwarding services in Thailand, the following theoretical implications can be formulated:

(1) Extended application of UTAUT model: This study reinforces the robustness of the modified UTAUT model in predicting technology adoption behaviors within the logistics and supply chain management context. It underscores the predictive power of variables such as performance expectancy, effort expectancy, social influence, perceived risk, and facilitating conditions across diverse organizational settings.

(2) Insights into technology adoption drivers: By identifying and validating factors influencing adoption intentions, such as perceived performance benefits and ease of use, this research provides deeper insights into the cognitive and motivational aspects that shape technology adoption decisions. This contributes to refining theoretical frameworks on technology acceptance by highlighting the nuanced interplay of these factors.

(3) Contextual understanding in logistics: This study enriches the understanding of technology adoption in the logistics industry, emphasizing industry-specific challenges and opportunities. It underscores the importance of organizational readiness, social influences, and perceived risks as critical factors requiring tailored strategies for successful implementation of new technology platforms.

(4) Implication for risk management strategies: This study's findings on the negative impact of perceived risk on adoption intentions emphasize the critical role of effective risk management strategies in technology adoption initiatives. This prompts further exploration into strategies for mitigating risks and integrating them into adoption frameworks to alleviate user concerns and enhance adoption rates.

(5) Generalizability and transferability of findings: The research findings contribute to the generalizability of technology adoption theories across various contexts, providing insights applicable to similar industries and technological innovations. This supports broader applications of theoretical frameworks in understanding and predicting technology adoption behaviors across different organizational environments.

These theoretical implications not only advance academic understanding of technology adoption processes but also offer practical guidance for stakeholders in the logistics sector.

They can help in devising effective adoption strategies, improving operational efficiencies, and fostering growth driven by innovation.

6. Conclusions

6.1. Research Conclusions

This study's findings significantly contribute to understanding the factors influencing the adoption an online platform for freight forwarding services among business customers in the Thai market. The research concludes that performance expectancy (PE), effort expectancy (EE), social influence (SI), perceived risk (PR), and facilitating conditions (FCs) are critical determinants of adoption intention. Additionally, this study reveals a moderating effect of firm size on the relationship between social influence (SI) and intention to use (IU), indicating that larger firms may be more influenced by social factors in their adoption decisions.

These findings have several implications for both theory and practice. Theoretically, this study extends the UTAUT model by incorporating perceived risk (PR) as an additional main factor and firm size as a moderating variable, providing a more comprehensive understanding of technology adoption in the logistics industry in the Thai context. Practically, the results can guide freight forwarding service providers in developing tailored strategies to promote the adoption of online platforms, such as emphasizing the performance benefits, simplifying the user experience, addressing social influences, mitigating perceived risks, and enhancing facilitation conditions.

Overall, this research contributes valuable insights that can inform the development and implementation of an online platform for freight forwarding services, ultimately enhancing the efficiency and competitiveness of the logistics industry in Thailand.

6.2. Limitations and Future Research Direction

This study has several limitations that present opportunities for future research. Firstly, the cross-sectional design, while useful for capturing a snapshot of adoption perceptions, restricts understanding of how these decisions evolve over time. Longitudinal studies could provide valuable insights into the dynamic nature of adoption decisions. Secondly, the focus on the Thai market may limit the generalizability of the findings. Replicating this study in other countries and cultures would enhance the external validity of the results.

Another limitation is the sample composition, which included more respondents from SMEs than large enterprises. This imbalance could have influenced the results, reflecting the predominance of small and medium-sized companies in the Thai market. It suggests the need for a more balanced sample in future studies to enhance the robustness of findings regarding moderator effects. While full measurement invariance testing was not conducted due to limitations in the Thai industry environment and time constraints, future research should consider employing larger sample sizes with balanced group distributions and conducting thorough measurement invariance testing to strengthen the validity of findings in multigroup analysis (MGA).

Additionally, due to resource constraints including a limited time and budget, a comprehensive statistical power analysis was not conducted. Addressing this limitation in future research would ensure that sample sizes are adequately determined to minimize the risk of Type II errors [100]. While the UTAUT model identifies several key factors influencing technology acceptance, it may overlook context-specific variables that are crucial in certain settings. Future research could explore additional moderators, such as industry sector and technology readiness, to further refine the understanding of adoption drivers and barriers within specific context. To investigate indirect effects and more intricate interactions between components, future research should include a mediating variable of intention to use between exogenous variables. This approach will allow for a more thorough comprehension of the phenomenon being studied.

Author Contributions: Conceptualization, N.P. and W.C.; methodology, N.P., W.A. and W.C.; validation, W.A. and W.C.; formal analysis, N.P.; investigation, N.P.; writing—original draft preparation, N.P. and W.C.; writing—review and editing, N.P., W.A. and W.C.; visualization, W.A. and W.C.; supervision, W.A. and W.C. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Data Availability Statement: The data presented in this study are available on request from the first author. The data are not publicly available due to ethical restrictions.

Acknowledgments: This research was partially supported by Chiang Mai University.

Conflicts of Interest: The authors declare no conflicts of interest.

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