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Article

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OPERATIONS, INFORMATION & TECHNOLOGY | RESEARCH ARTICLE

Will customers adopt last-mile drone delivery services? An analysis of drone delivery in the emerging market economy

Charlie Chen¹, Steve Leon² and Peter Ractham^{3*}

Abstract: Drone delivery services are novelty concepts to most people in emerging market economies. To gain competitive advantages, retailers in emerging market need to be proactive in understanding the key factors contributing to the acceptance of last-mile drone delivery services by general users. This study offers personal and social perspectives of the adoption of drone delivery services by Thai users. A total of 391 respondents participated in an online survey. The PLS-SEM method was used to perform the data analysis. The analysis results show that personal innovativeness and opinion passions are antecedents for Thai users' perceived ease of use. However, these two antecedents do not affect Thai users' perceived usefulness for drone delivery services. In addition, perceived privacy risk has a negative moderating effect on the relationship between PEOU and the adoption of drone delivery services. In contrast, Thai users' perceived privacy risk has no significant moderating effect on the relationship between PU and the intention to adopt drone delivery services. Lastly, PEOU has a significant positive effect on the intention of users to adopt drone delivery services, whereas PU does not have any significant effect. These findings provide theoretical and practical implications on the

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PUBLIC INTEREST STATEMENT

Traditional retailers in emerging markets need to be proactive in understanding the key factors contributing to the acceptance of last-mile drone delivery services by their customers. The knowledge gained can help retailers in the emerging economy gain future competitive advantages in improving their customer experience by through drone delivery services. The results of this study indicate that a customer's intention to adopt last-mile drone delivery services is affected mostly by perceived ease of use. The stronger a customer's perceived ease of use for drone delivery services, the greater its influence on the adoption intention drone service providers ought to clearly communicate to their customers on how easy the process of drone delivery could be. Building trust with customers could help retailers continue to use drone delivery services. Transparency, regular communication, and a social presence can assist an organisation in establishing its trusted service provider status.

moderating effect of perceived privacy risks on the relationships between perceptions and the intention to adopt the last-mile drone delivery service.

Subjects: Production, Operations & Information Management; e-Business; Management of Technology & Innovation

Keywords: Drone delivery service; E-Commerce; emerging market; last mile e-commerce

1. Introduction

Thailand is renowned for its international hospitality industry. Thailand ranked eighth globally with more than 40 million international tourists in 2019 (Saxon et al., 2021). About 36 million people worked in the hospitality industry before the global pandemic. Since the pandemic began, the hospitality industry experienced a severe impact (Manakitsomboon, 2021). International passengers travelling to Thailand have declined by 95% during the pandemic. Local hotels could only fill 9% of their rooms (Saxon et al., 2021). The global pandemic also forces many traditional retailers in Thailand to close because of the national lockdown and other movement restrictions. Although few retailers can innovate and transform into e-business, most could not transform successfully. The vicious cycle continues to accelerate as the pandemic persistently prevails.

The emergence of Covid-19 has disrupted Thailand's global and local supply chains. The retailers cannot fill and deliver orders to customers because of national lockdown or delivery restrictions. The uncertainty of receiving orders has caused customer anxiety and dissatisfaction during the pandemic (Yaprak et al., 2021). A growing number of businesses, such as Zipline, started experimenting with drone delivery services to overcome the current challenges in last-mile delivery during the pandemic (Euchi, 2021). However, most customers in Thailand are not familiar with drone technology and its applications in the retailing business. Therefore, it is vital to investigate their perceptions of the last-mile drone delivery services and predict the mass acceptance of the innovative delivery method. Suppose That customers are receptive to the novelty concept. In that case, the traditional retailers can implement it to overcome the pandemic-related challenges and become competitive with the innovative drone technology.

Leading companies in the developed countries, such as Amazon, UPS and Domino's, have publicised their future endeavour of using drones to deliver packages to customers' premises fast (Iranmanesh & Raad, 2019). Amazon's Prime Air is a typical drone delivery service. As a result, customers in those countries are increasing their awareness of its potential benefits and risks. A recent survey shows that 16% of American customers are interested in using the last-mile drone delivery services (Kunst, 2019). In contrast, developing countries primarily use drones to help displaced and vulnerable populations to carry out humanitarian missions. For instance, the Thailand government has used drones to deliver life-saving medical supplies to remote communities (Laksham, 2019). African countries have used drones to execute search-and-rescue missions in disaster zones (Naidoo et al., 2011). The Japanese company Terra Drone employed drones to transport medical samples and quarantine supplies to help local Chinese governments to combat Covid-19 (Cozzens, 2020). Overcoming infrastructural inadequacies in developing countries is the primary reason for accepting drone delivery services.

The outbreak of Covid-19 accelerates the current demand for medical drone delivery and commodity delivery to the public, because of the national lockdown in developing countries (Chamola et al., 2020). The global pandemic provides business opportunities for traditional retailers in developing countries to leverage drones to deliver products to customers during the lockdown. However, commercial drone delivery is still at the inception stage in developing countries. Regulations and customer acceptance are two significant barriers to the general public's adoption of drone delivery services in developing countries. The global pandemic forces developing countries to make regulatory changes to reap the commercial benefits of drone

delivery services. As such, local businesses and customers have started to explore the business values of drone delivery services.

This study aims to understand the intention of local customers in developing country to adopt last-mile drone delivery services based on three frameworks: diffusion of innovations theory, word-of-mouth marketing, and the technology acceptance model. The findings of this study can help understand the possibility of realizing the last-mile drone delivery business opportunities such as contactless delivery, reduced risk of transmission during delivery, speed of delivery and cost savings for consumers in developing countries.

The following section will be a thorough literature review related to the relationships between the constructs. The literature review will lead to a conceptual formulation of a research model and hypotheses. The research methodology section will explain how the data was collected and analyzed to validate the proposed hypotheses. Theoretical and practical implications will be discussed based on the hypothesis test results. Lastly, limitations and future research directions will be discussed to conclude this study.

2. Theoretical framework and hypothesis development

2.1. Diffusion of innovations theory

Accepting a new technology or service takes different amounts of time for people, depending on their adoption segment. According to the diffusion of innovations theory, the technology adoption lifecycle has five sequential adoption segments: innovators, early adopters, early majority, late majority, and laggards (Rogers, 1976, 2010). Users in different adoption segments have varying demographic and psychological characteristics (Rogers et al., 2005). For instance, innovators tend to be more educated and risk-taking oriented. Early adopters are often younger and community leaders. The early majority are open to new ideas and active in the local community, but are somewhat conservative. The late majority is often less educated, more conservative, and less socially active. Laggards are the least educated and the most conservative people among these five groups. Each customer segment needs to overcome its hurdles or slope of enlightenment to have the pleasure of using a novelty technology (Van Petegem, 2021).

New products and services struggle to cross the chasm between the adjacent adoption segments (Wood, 2017). When companies cannot cross the chasm, they will not build enough momentum to introduce the new products/services to the mass market. When customers in each adoption segment overcome the adoption hurdles and begin to experience benefits, they will recommit efforts to move forward to cross the chasm and help more new customers enter the following customer segment (Van Petegem, 2021).

Drone delivery services are still at the mercy of a few innovators in developing countries. Therefore, the challenges of crossing the chasm are still paramount for users of drone delivery services. Drone delivery service providers need to help users in developed countries to cross the chasm between innovators and the early majority. In contrast, drone providers need to educate customers in developing countries to become innovators for drone delivery services. For instance, users need to be aware that drone food delivery services can help the hospitality industry circumvent the current challenges (Hwang et al., 2020). In the meantime, the technological solution can help combat traffic and air pollution in developing countries (Hwang & Kim, 2019). However, the recent study shows that drone delivery is still a novelty idea not ready to take off simply because users are not familiar with the technology, regulations and its related privacy and security issues (Shafiee & Bazargan, 2018; Shafiee et al., 2017; Tom, 2020). To increase the number of innovators accepting drone delivery services, their vendors can target customers with high perceived innovativeness and leverage word-of-mouth marketing strategy (Hwang & Kim, 2021) to make them aware of the drone delivery service opportunity.

2.2. Word-of-Mouth (WOM) theory

Social media becomes a powerful medium to influence users' perception of a new product or service before adopting it. Electronic word-of-mouth (e-WOM) is the primary reason for the impact of social media marketing on increasing users' awareness about new products and services. e-WOM concept builds upon word-of-mouth (WOM) behaviors through which consumers exchange product- and brand-related information (Kozinets et al., 2010; Rosen, 2002). When using social media, users convey mutual interest or use shared language to discuss with others in the interested group about specific products/services. The common interest or shared languages help build the interpersonal trust, which is instrumental in building brand awareness and increase purchase intention of customers (Engel et al., 1969)

Many studies show that e-WOM has a positive influence on increasing brand images (Siddiqui et al., 2021), brand awareness (Maria et al., 2019), and online purchase decisions (AL-JA'AFREH & AL-ADAILEH, 2020; Buttle, 1998). When a user is interested in a product or service, he or she starts talking about it to people with whom they have close relationships. When people know and trust each other and share information on a new product or service, they tend to believe and choose to accept it. For instance, online reviews have gained much influence on how customers engage and purchase new products (Daga, 2020). A Nielsen study shows that 92% of people trust recommendations from friends and family than other forms of advertising (Glover, 2021). People connect socially and emotionally. When people interact and share information on a new product, an initial interaction will often lead to a cascade of follow-on interactions. The snowballing effect can emerge from e-WOM if the shared product information is credible, social, repeatable, measurable, and respectful.

Most users in developing countries are not familiar with drone delivery services as they have limited user experience. E-WOM is thus a potentially effective marketing strategy to have innovators initiate conversations on the service with their close friends who are innovators or early majority groups.

2.3. Technology acceptance model

Information systems (IS) literature has adopted the technology acceptance model (TAM) to illustrate how users adopt new technology (Davis, 1985; Davis et al., 1989). Before using new technology, users need first to form their intention to use it (Legris et al., 2003; Liu et al., 2020). To increase the adoption intention, users often rely on their general impression or attitude of the new technology. The chain structure of causal effects is evident in the adoption of many new technologies, such as driverless car (Koul & Eydgahi, 2018), mobile banking (Lule et al., 2012), and crowdfunding (Jaziri & Miralam, 2019). Therefore, it is essential to gauge users' perceptions toward the adopted technology. There are two general forms of perceptions: perceived ease of use (PEOU) and perceived usefulness (PU; Davis et al., 1989; Lee et al., 2003). PEOU refers to the degree to which a user believes it is easy to use the adopted information system (Davis, 1989). PU refers to the degree to which a user believes that he/she can enhance their productivity or job performance with the adopted technology (Amin et al., 2014). These two perceptions are crucial to be measured when users have limited direct exposure to the adopted information systems. Most people in developing countries have limited contact experience with drone delivery services because they are not introduced to the public yet. Therefore, these two forms of perceptions can help understand whether they can increase the intention of Thai users to adopt drone delivery services, thereby contributing to the actual use of these services.

2.4. The impact of opinion passing on users' perceptions of drone delivery services

Word-of-mouth (WOM) behavior refers to consumers exchanging product and brand-related information with each other (Kozinets et al., 2010). Interest groups or online community members rely on WOM to convey mutual interest or shared language about specific products/services. Since members share the same language in the group or community, members are more likely to be influenced when deciding to purchase a product (King et al., 2014).

WOM is also influential in the process of purchasing an innovative product or service, because members within the same interest group or online community tend to trust each other (Kozinets et al., 2010). When general users first learn about drone delivery services, they are unaware of their capabilities and limitations (Knobloch & Schaarschmidt, 2020). At the early adoption phase, word-of-mouth behaviors are even more critical because it allows communication about the technology between user segments with different degrees of personal innovativeness. User segments next to each other can understand better the product and brand-related product information than user segments farther from one another.

Social media transforms the WOM process into electronic WOM (e-WOM), a many-to-many communication process. Users are recipients and producers of product-related information on social media (Chung & Koo, 2015; Kozinets et al., 2010; Shafiee, 2020). E-WOM consists of three elements: opinion-giving, opinion-seeking, and opinion-passing. Opinion-giving and opinion-seeking activities often occur offline, whereas opinion-passion can occur online quickly (Gilbert & Karahalios, 2009). Opinion passing is essential when introducing new technology because it relies on users who experience and share credible information about the technology (Berger, 2014). The credible information is social capital entailing cognitive (what), relational (who), and structural (where) information that can promote positive social interaction and the final decision of adopting new information technology (Tsai & Ghoshal, 1998). After receiving information about drone delivery services from close friends, users are more likely to form high PEOU and PU about those services. Thus, we propose:

H1: Opinion passing has a positive impact on the increase of users' perceived ease of use for drone delivery services

H2: Opinion passing has a positive impact on the increase of users' perceived usefulness for drone delivery services

2.5. The impact of personal innovativeness on users' perceptions of drone delivery services

The diffusion of innovation theory asserts that users adopt new technology over time and can be segmented into five successive groups according to the adoption timeline: innovators, early adopters, early majority, late majority, and laggards (Rogers, 2010). Users respond to innovation differently. Some users are excited about using new technologies, whereas others are reluctant. Innovative users, such as innovators and early adopters, are early to adopt new technology even before the majority accepts it.

The current IT and marketing literature shows that personal innovativeness is a strong determinant of innovation adoption behaviors. Personal innovativeness consists of two dimensions: global innovativeness and domain-specific innovativeness. Users with a higher willingness to change possess a higher global innovativeness trait (Hurt et al., 1977). However, the general personality trait has a lower predictive power of specific technology adoption behavior. Domain-specific innovativeness can effectively investigate users' technology adoption behaviors within a narrow domain of activity (Goldsmith & Hofacker, 1991). This study aims to understand what motivates the general public to adopt drone technology for delivering products to their homes. Therefore, it is crucial to assess the impact of both global and domain-specific innovativeness traits on the adoption behaviors of general users (Greenhalgh et al., 2004). Users with high innovativeness traits are more likely to form high PEOU and PU of drone delivery services because they often embrace new ideas. Thus, we propose:

H3: Personal innovativeness has a positive impact on the increase of users' perceived ease of use for drone delivery services

H4: Personal innovativeness has a positive impact on the increase of users' perceived usefulness for drone delivery services

2.6. The impact of users' perceptions on the intention to use drone delivery services

It is imperative to understand what factors can increase users' intentions to adopt new technology because it can help predict their actual usage (Davis et al., 1989). For instance, farmers in Germany have a low adoption rate of agricultural drones. When farmers are aware of the technology and its specific farming applications, they tend to increase their PEOU, PU, and confidence, thereby positively impacting their intention to adopt agricultural drones (Michels et al., 2021).

The general users in developing countries are similar to those farmers in Germany. The adoption rate of last-mile drone delivery services is minimal for users in those countries. Most users are not aware of this innovative service and how they can benefit from it. The movement restrictions create an opportunity for the public to discuss this innovative service to overcome the current restrictions. After learning more about the last-mile drone delivery services, users in developing countries are more likely to increase their PEOU and PU for these services. Thus, we propose:

H5: Perceived ease of use has a positive impact on the increase of users' intention to adopt drone delivery services

H6: Perceived usefulness has a positive impact on the increase of users' intention to adopt drone delivery services

The moderating effect of perceived privacy risks on the relationship between user perceptions and intention to adopt drone delivery services

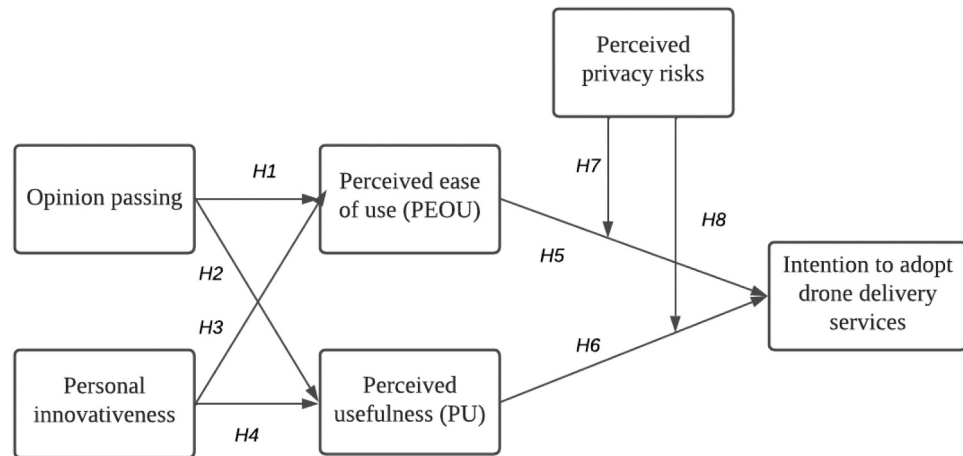
While many users recognize the potential benefits of last-mile drone delivery services, they are reluctant to adopt them because of their high perceived privacy risks. In a survey, about 88% of 1,500 Americans expressed severe privacy concerns about using drone delivery services (Covington, 2021). One top reason is the ability of delivery drones to take pictures of their property, their surroundings, and children playing in the backyard. Another reason is that the data collected from the premises and its proximity can be used as a marketing tool to make future purchase recommendations to the residents. For instance, Amazon's delivery drones can scan, capture, and process data about a home and its neighbors and recommend products and services to the homeowner and neighbors. Homeowners have no rights to the use of airspace over their properties. Therefore, any company can freely use their delivery drones to perform the essential delivery job and collect personal data related to the job without needing permission from the homeowners.

Perceived privacy risks are users' willingness to share their data with others when they are informed about the likelihood of potential privacy harm resulting from using drone delivery services (Akkarakantorn, 2020). Consequently, users will develop perceptions about the potential risks of using drone delivery services when they learn more about the capability of delivery drones. Users may reconsider the PEOU and PU of drone delivery services when perceived privacy risks are high. The increased privacy risks can result in the decreased impact of PEOU and PU on the intention of users to adopt drone delivery services. Thus, we propose:

H7: Perceived privacy risks have a moderating impact on the relationship between users' perceived ease of use and their intention to adopt drone delivery services

H8: Perceived privacy risks have a moderating impact on the relationship between users' perceived usefulness and their intention to adopt drone delivery services

Figure 1. Is the research model.



The above discussion leads to the development of our research model (Figure 1).

2.7. Research Methodology

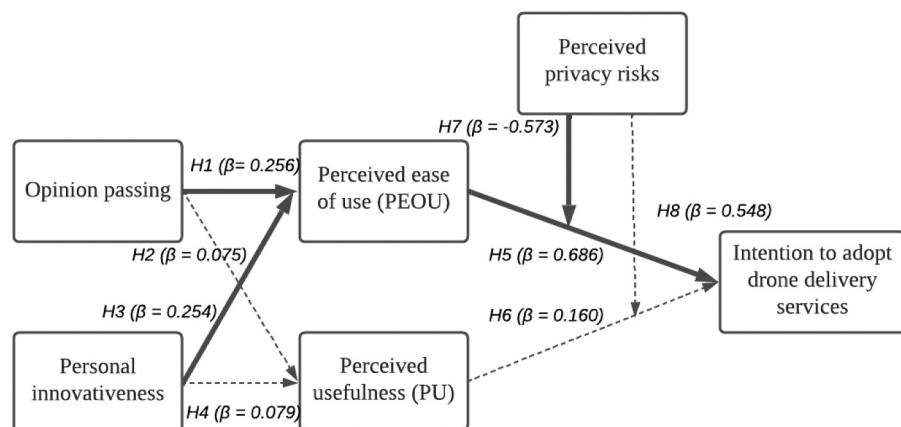
This study adopts the quantitative analysis approach, using an online survey to collect data and test the proposed hypotheses. The collected data was analyzed with the Partial Least Squares—Structural Equation Modelling (PLS-SEM). The statistical tool enables us to evaluate the research model's structure and measurement of the hypothesized relationships in the research model.

2.7.1. Data collection

Bloomberg business news has named Thailand the top emerging market for 2021 (OECD, 2021). Thailand has one of the largest Foreign Direct Investment (FDI) and very robust e-commerce market worth more than \$27.7 billion in 2020 and the growth is expected to rise by about 8% until 2023. Its e-commerce market is the second largest following only Indonesia within the ASEAN region. Thus,

Figure 2. A smartPLS analysis result.

—— The hypothesized relationship is insignificant
 ——— The hypothesized relationship is significant.



----- The hypothesized relationship is insignificant
 ——— The hypothesized relationship is significant

Table 1. Demographical analysis

Questions	Variables	THAILAND	
		Frequency	Per cent
Gender	Male	109	27.9
	Female	281	72.1
How many times per month do you shop online?	Never	13	3.3
	1–5 times	286	73.3
	6–10 times	55	14.1
	More than 10 times	36	9.2
Do you have access to reliable and timely transportation?	No	35	9.0
	Yes	355	91.0
Have you ever heard the noise levels of drones?	No	195	50.0
	Yes	195	50.0
Have you ever been in close proximity to a flying drone?	No	154	39.5
	Yes	236	60.5
Which best describes the distance between your home and your neighbours?	Neighbours are not close at all	8	2.1
	Moderately close neighbours	30	7.7
	Very close neighbours	97	24.9
	Extremely close neighbours	255	65.4

Thailand represents an interesting setup for studying different aspects of new technology to enable the thriving e-commerce market in an emerging market (Chiu, 2019; Kirk et al., 2016).

This study aims to understand the intention of Thai users to adopt the last-mile drone delivery services. Therefore, all our participants reside in Thailand and are Thai citizens. To draw survey participants from diverse and different economic backgrounds, an online survey was disseminated through popular Thai e-commerce related social media outlets and web forums. Also the survey targeted potential Thai users of last-mile drone delivery services based on their online shopping experience, having direct contact with drones, and geographical proximity. One of the authors, has been an active participant of popular social media outlets and web forums, often starting discussion about various new technology relevance to e-commerce topics. Various online video on Drone service delivery were posted in social media outlets and web forums to encourage lively conversations between the members. The author often updated the content with new drone delivery service news on the sites and forum to keep the level of interests in the topic as well as recruiting the survey participants.

The surveys were posted for 4 months between October 2021–December 2021. A total of 407 subjects participated in the survey however 17 subjects stated that they are not interested in using drone delivery services. Thus, there were 390 valid survey (Table 1). Respondents were requested to report their most recent online shopping experience. About 96.7% of subjects in this study had online shopping experiences. In addition, 23.3% of Thai subjects shopped online more than six times per month. About 91% of respondents have access to reliable and timely transportation. About 50% of subjects have similar close contact experiences with drones based on the question, “Have you ever heard the noise levels of drones?”

Table 2. Constructs and items

Construct	Item	Source
Perceived Ease of Use (PEOU)	<ul style="list-style-type: none"> • It is easy for me to become skillful in using a drone delivery service. • I find drone delivery services easy to use. • I find it easy to use drone delivery services to do what I want to do. • Learning to use drone delivery services is easy for me. 	Davis (1989)
Personal Innovativeness (PI)	<ul style="list-style-type: none"> • If I heard about a new information technology, I would look for ways to experiment with it. • Among my peers, I am usually the first to try out new information technologies. • I like to experiment with new information technologies. 	Agarwal and Prasad (1998)
Perceived Privacy Risk (PPR)	<ul style="list-style-type: none"> • Privacy would be at risk when drones are used for delivery service. • There would be a high potential for privacy loss associated with using drones for delivery service. • There would be too much privacy uncertainty associated with using drones for delivery service. 	Li et al. (2016)
Perceived Usefulness (PU)	<ul style="list-style-type: none"> • I would find that a drone delivery service would be useful in my daily life. • Using a drone delivery service would make my lifestyle convenient. • Using a drone delivery service would save me time. • Using a drone delivery service would make my life easier. 	Davis (1989)
Opinion Passing (OP)	<ul style="list-style-type: none"> • When I receive product-related information or an opinion from a friend, I will pass it along to my other contacts on social networks. • On social networks, I often influence my contacts' opinions about products. • I like to pass along interesting information about products from one group of my contacts on my "friends" list to another on social networks. 	Wang et al. (2016)

(Continued)

Table 2. (Continued)

Construct	Item	Source
Behavioural Intention (INT)	<ul style="list-style-type: none"> • If given a chance, I plan to use the drone delivery service frequently. • I predict I will use a drone delivery service regularly. • I intend to use a drone delivery service in the future. • If given a chance, I will allow drones to deliver products to me. 	Davis (1989)

2.7.2. Data collection instrument

The items were adopted from previous studies related to the marketing, social network, and technology acceptance model (TAM) and modified to fit the context of drone service delivery (Table 2). The adopted multi-item scales increased validity and reliability (Peter, 1979). Five-point Likert scales were used to collect item responses anchored by 1 = “strongly disagree” and 5 = “strongly agree”. Non-substantive changes were made to the survey after several subjects who would be typical respondents completed the online survey in a pre-test.

2.7.3. Path and model estimation

SmartPLS (C. Ringle et al., 2015) was used to validate the hypotheses, evaluate internal consistency and reliability, and calculate the model’s path coefficients. The statistical tool uses PLS-SEM methodology to examine the causal and effect relationships between constructs (Henseler et al., 2009). PLS-SEM is a commonly-used analysis method to examine formatively measured latent variables in the research model (C. M. Ringle et al., 2012). Moreover, PLS-SEM’s assumptions are less restrictive in sample sizes, measurement scales, and residual distribution (Chin, 1998). These issues are less likely to lead to estimation problems (Goh & Sun, 2014).

2.7.4. Measurement model

We performed the tests of internal consistency and for convergent and discriminant validity for the measurement model. The items used to measure each construct showed high levels of internal consistency reliability.

Factor loading measures of all constructs (Table 3) exceed the recommended minimum value of 0.70 (Hair et al., 2006). Cronbach’s α values range from 0.7613 to 0.8667 (Table 4) and also exceed the threshold of 0.70. Convergent validity was evaluated with composite reliability and average variance extracted (Chin, 1998; Fornell & Larcker, 1981). Composite reliability values are above the threshold value of 0.70. The average variance extracted (AVE) values are 0.6764 and above, exceeding the recommended minimum threshold of 0.50 (Fornell & Larcker, 1981).

All latent constructs show sufficient discriminant validity because the loadings and cross-loadings of factor analysis of each item load highly within its corresponding latent construct. The reliability of all indicators is high because all indicator loadings are above the threshold value of 0.70 (Chin, 2010). Discriminant validity is further ascertained because the square root of the AVE for each construct is greater than the correlations between the constructs and all other constructs (Table 5; Fornell & Larcker, 1981). For instance, the square root of the AVE values for PI (0.9366) and PPR (0.9284) is greater than the inter-correlation (0.1139) between PI and PPR. Thus, high discriminant validity is clear in the proposed research model.

Table 3. Factor loading measures

Construct	Items	Factor loadings
Behavioral intention (INT)	INT1	0.8410
	INT2	0.8354
	INT3	0.8461
	INT4	0.7961
Opinion Passing (OP)	OP1	0.8085
	OP2	0.8176
	OP3	0.8410
Perceived ease of use (PEOU)	PEOU1	0.8401
	PEOU2	0.8487
	PEOU3	0.8792
	PEOU4	0.8109
Perceived innovativeness (PI)	PI1	0.9290
	PI2	0.9439
Perceived privacy risk (PPR)	PPR1	0.9214
	PPR2	0.9353
Perceived usefulness (PU)	PU1	0.8137
	PU2	0.8991
	PU3	0.7778
	PU4	0.8697

2.7.5. Hypothesis testing results

This study adopted the SmartPLS 2.0 software to conduct a PLS-SEM test to calculate the research model's estimated path coefficients, path significance, and R^2 values (Figure 2). The model was evaluated with 391 participants in Thailand. The path analysis result showed that 46.4% (R^2) of the variation in intention to adopt drone delivery services was explained by the model's PEOU and PU constructs. As for the moderating effect of PPR on the relationships between PEOU, PU and INT. PPR was used as a moderator variable to assess whether PPR changes the strength or the direction of the relationships between PEOU and INT, and PU and INT in our research model.

Opinion passing has a significant and positive effect on Thai users' *perceived ease of use* for drone delivery services ($\beta = 0.256$; $t = 4.498$). Thus, *H1* is supported (Table 6). However, *Opinion passing* has no significant effect on the *perceived usefulness* of Thai users for drone delivery services ($\beta = 0.075$; $t = 1.236$). Thus, *H2* is rejected. *Personal innovativeness* significantly affects Thai users' *perceived ease of use* for drone delivery services ($\beta = 0.254$; $t = 4.432$). Thus, *H3* is supported. However, *Personal innovativeness* has no significant effect on the *perceived usefulness* of Thai users for drone delivery services ($\beta = 0.079$; $t = 1.257$). Thus, *H4* is rejected. *Perceived ease of use* significantly affects Thai users' *intention to adopt drone delivery services* ($\beta = 0.686$; $t = 3.269$). Thus, *H5* is supported. However, *perceived usefulness* has no significant effect on the *intention of Thai users to adopt drone delivery services* ($\beta = 0.160$; $t = 0.820$). Thus, *H6* is rejected. *Perceived privacy risk* has a negative moderating effect on the *relationship between perceived ease of use and the intention of Thai users to adopt drone delivery services* ($\beta = -0.573$; $t = 1.928$). Thus, *H7* is supported. *Perceived privacy risk* has a positive moderating effect on the *relationship between perceived ease of use and the intention of Thai users to adopt drone delivery services* ($\beta = 0.548$; $t = 1.731$). This finding is contrary to the positive direction of the hypothesized moderating effect. Thus, *H8* is rejected. In summary, four out of eight hypotheses are supported.

Table 4. Construct and measurement quality indicators

	Mean	Standard Deviation	AVE	Composite Reliability	Cronbach's Alpha
Behavioural Intention (BI)	3.6042	.65156	0.6887	0.8984	0.8492
Opinion Passing (OP)	3.3248	.84492	0.6767	0.8626	0.7613
Perceived Ease of Use (PEOU)	3.4847	.67279	0.7141	0.9089	0.8667
Perceived Innovativeness (PI)	3.0217	1.01282	0.8773	0.9346	0.8602
Perceived Privacy Risks (PPR)	3.6709	.70951	0.8619	0.9258	0.8401
Perceived Usefulness (PU)	3.9495	.63663	0.7093	0.9069	0.863

Note: AVE is average variance extracted

3. Discussion

Given that there is an increasing number of companies exploring the use of drones for last-mile delivery, investigating consumer willingness to adopt this mode of delivery is prudent. While studies have examined optimization of drone delivery routing (Huang et al., 2020) and scheduling (Torabbeigi et al., 2020), studies investigating the adoption of last-mile drone delivery considering consumers' opinion passing (e-WOM), personal innovativeness, perceived ease of use, and perceived privacy risk is negligible. Furthermore, this study is one of the first studies to investigate drone delivery service in Thailand. The research model was constructed on the Diffusion of Innovations Theory, Word-of-Mouth Marketing, and Technology Acceptance Model frameworks. The findings in this study have implications to theory and provide managerial insights into last-mile drone delivery services, with the aim of improving successful of implementation of these services, particularly in developing nations.

3.1. Implications for theory

This research contributes theoretically to the emerging stream of last-mile drone delivery adoption research. Given the scarceness of research in this stream currently, it is unclear from previous research which behavioral factors influence adoption of last-mile drone delivery. The main theoretical contributions of this research come from several directions. First, this research empirically tests an extended TAM model to adoption of drone delivery service, including new constructs labelled opinion passing and personal innovativeness. Second, this research examines perceived ease of use and perceived usefulness—constructs that appear in other TAM research, though often

Table 5. Correlations and discriminant validity test results

	BI	OP	PEOU	PI	PPR	PU
BI	0.8299					
OP	0.2598	0.8226				
PEOU	0.5074	0.3665	0.8450			
PI	0.2252	0.4347	0.3650	0.9366		
PPR	0.0589	0.1659	0.0331	0.1139	0.9284	
PU	0.6112	0.1096	0.4003	0.1116	0.0276	0.8422

Note: Square root of AVE appears on the diagonal in bold

Table 6. Hypothesis test results

Hypothesized Paths	Path Coefficients	T-statistics
H1. OP → PEOU	0.256	4.498***
H2. OP → PU	0.075	1.236
H3. PI → PEOU	0.254	4.432***
H4. PI → PU	0.079	1.257
H5. PEOU → INT	0.686	3.269***
H6. PU → INT	0.160	0.820
H7. PPR*PEOU → INT	-0.573	1.928*
H8. PPR*PU → INT	0.548	1.731

Notes: *p < 0.05; **p < 0.01; *** p < 0.001

not included in drone research—and therefore, have not been adequately investigated. A final contribution comes from providing depth to the results by exploring perceived privacy risk moderation effects.

This study examined opinion passing, which has not been examined previously in drone delivery adoption research. The current study examined the impact of opinion passing on intention to adopt drone delivery services through perceived ease of use and perceived usefulness. While opinion passing had a significant effect on perceived ease of use, it did not have an effect on perceived usefulness. Though, a study by Cheung et al. (2021), in a Hong Kong healthcare wearable technology setting, found that opinion seeking had a positive and significant effect on both perceived ease of use and perceived usefulness.

Additionally, the current study examined the impact of personal innovativeness on intention to adopt drone delivery services through perceived ease of use and perceived usefulness. Similarly, to opinion passing, personal innovativeness had a significant effect on perceived ease of use, though it did not have an effect on perceived usefulness. Alternatively, Chayomchai (2020) in an online technology acceptance setting, found that personal innovativeness was significant for both perceived ease of use and perceived usefulness, though the effect was stronger for perceived ease of use. Yoo et al. (2018) examined personal innovativeness's influence on intention to use drone delivery through "attitude toward drone delivery", and found a positive and significant effect.

Perceived ease of use and perceived usefulness constructs have limited exploration in drone delivery services. Moreover, they are often indirectly modelled through attitude rather than measured directly to intention to adopt drone delivery services. This study found that perceived ease of use was influential on intention to adopt drone delivery service when modelled directly. Yoo et al. (2018) modelled complexity on the intention to adopt drone delivery service, a proxy construct for perceived ease of use, and found mixed results. Yaprak et al. (2021) found that perceived ease of use had a significant effect when modelled through attitude. While there have been many studies investigating perceived usefulness on adoption of technology, few studies have examined this relationship in the domain of last-mile drone delivery, and those that have show mixed results. The current study found that perceived usefulness is not influential on intention to adopt drone delivery service. However, Mathew et al. (2021) found a significant result, whereas Yoo et al. (2018) found mixed results. Further, Yaprak et al. (2021) found that perceived usefulness was significant when modelled through attitude.

Examining perceived privacy risk in drone settings often elicits conflicting results, thus making perceived privacy risk an unreliable predictor. Often, perceived privacy risk is modelled indirectly through an attitude construct or some other construct. Mathew et al. (2021) found a significant result between privacy risk and attitude, though it was marginally influential. Yoo et al. (2018) found conflicting results, where perceived privacy risk was significant when attitude was not

included in the model and was not significant when attitude was included in the model. Zhang et al. (2019) did not find a significant path between perceived privacy risk and trust. A study by Leon et al. (2021) examined the direct effect of perceived privacy risk on intention to adopt drones for delivery and found a marginally significant and negative effect. Even though some drone studies have examined perceived privacy risk, it appears that it has not been investigated as a moderator to intention to adopt drone delivery. This study found that perceived privacy risk has a negative and significant moderating effect on the relationship between perceived ease of use and intention to adopt drone delivery services. However, perceived privacy risk was found to have a non-significant moderating effect on the relationship between perceived usefulness and intention to adopt drone delivery services.

3.1.1. Implications for practice

Drone service providers are busy trying to introduce last-mile drone delivery services. Yet, barriers may persist in their quest. Many studies have highlighted some benefits of using drone delivery services such as reduced environmental pollution, delivery time, road congestion, and transportation cost (Park et al., 2018). However, consumers may still be hesitant to adopt drone delivery service. To achieve these benefits and improve the success of drone delivery implementation, initiatives should focus on improving perceived ease of use and minimizing perceived privacy risk.

The results of this study indicate that a customer's intention to adopt last-mile drone delivery services is affected mostly by perceived ease of use. The stronger a customer's perceived ease of use for drone delivery services, the greater its influence on the adoption intention drone service providers ought to clearly communicate to their customers on how easy the process of drone delivery could be. There are several ways drone delivery providers could improve "ease of use". They include improving the user interface between the customer and mobile apps and websites, providing push notifications to customers regarding delivery times, and suggesting convenient customer preferred drop-off points. Increasing the perception of these benefits can reinforce perceived ease of use and thereby improve customers' intentions to adopt drone delivery services. Additionally, opinion passing and personal innovativeness have a strong influence on perceived ease of use. Therefore, organizations that assist and promote opinion passing (e-WOM) through customer social networks ought to see an increase in willingness to adopt drone delivery services. In particular, if organizations can reach innovators, early adopters, and even early majority technology users, and incentivize them to pass along positive messaging through e-WOM, these organizations may see even more in terms of response to drone delivery service acceptance and adoption.

Since perceived privacy risk acts to negatively influence intention to adopt drone delivery service, it is wise for legislatures and organizations to create a technologically safe environment. There are multiple ways to accomplish this. One way is to create laws and regulations and enforce them as a deterrent to privacy invasion. Second, organizations can build trust between themselves and their customers. Since trust is described as a leap of faith when users lack complete information (Bahmanziari et al., 2003), building trust with consumers could help them commit to using and continuing to use drone delivery services. Organizations might develop unambiguous policies and demonstrate adherence to these policies to build trust. Transparency, regular communication, and a social presence can assist an organization in establishing its trusted service provider status.

4. Conclusion

This study investigated the adoption of last-mile drone delivery in Thailand, using the frameworks of Diffusion of Innovations Theory, Word-of-Mouth Marketing, and Technology Acceptance Model. Personal innovativeness, opinion passing, perceived privacy risk, along with perceived ease of use and perceived usefulness, were the factors examined as they relate to intention to adopt drone delivery. This study found that consumer acceptance of delivery by drone increases if they perceive drone delivery to be easy. Ease of use is influenced by personal innovativeness and opinion passing.

Despite the careful attention to the research methods, this study has a few limitations that can be improved by future research. First, the proposed research model explained 46.4% of the variance in intention to adopt drone delivery services by the model's perceived ease of use and perceived usefulness constructs. Therefore, some factors not examined in this study might improve the model's explanatory nature. These factors could include legislation, perceived safety, and trust. Second, this study was limited to Thailand, thus further research to test this study's generalizability is needed. Third, this study examined individuals' perceptions, where respondents have not previously used drones for last-mile delivery, therefore, this study provides intention to adopt insights only. Finally, since last-mile drone delivery is in its infancy and nearly non-existent, the current study investigated opinion passing. Later, when consumers have experienced drones for last-mile delivery, opinion giving may be another relevant construct to investigate.

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