FACTORS INFLUENCING ADOPTION AND USAGE PROBABILITY OF AUTOMATED PARCEL LOCKERS

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ปัจจัยส่งเสริมการใช้และความน่าจะเป็นของการใช้งานตู้รับส่งพัสดุอัตโนมัติ

น.ส.อรวีร์ ทองคำ

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรดุษฎีบัณฑิต
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อรวีร์ ทองคำ : ปัจจัยส่งเสริมการใช้และความน่าจะเป็นของการใช้งานตู้รับส่งพัสดุอัตโนมัติ. (FACTORS INFLUENCING ADOPTION AND USAGE PROBABILITY OF AUTOMATED PARCEL LOCKERS) อ.ที่ปรึกษาหลัก : รศ. ดร.มาโนช โลหเตปานนท์, อ.ที่ปรึกษาร่วม : รศ. ดร.พงศา พรชัยวิเศษกุล

ในการศึกษานี้ผู้วิจัยได้นำเสนอแบบจำลองโครงสร้างสมการวิเคราะห์การถดถอยเชิงเส้นพหุคูณ (Multiple Linear Regression) และแนวทางที่เหมาะสมสำหรับการทำนายความน่าจะเป็นในการใช้ตู้รับพัสดุอัตโนมัติในเขตกรุงเทพมหานครฯ โดยแบบจำลองนี้มีวัตถุประสงค์เพื่อหาปัจจัยที่ส่งผลต่อการเพิ่มความน่าจะเป็นการใช้งานตู้รับพัสดุอัตโนมัติ นอกจากนี้ ยังได้พิจารณาวิเคราะห์โครงสร้างปัจจัยเชิงสาเหตุ (Structural Equation Model) ที่มีอิทธิพลต่อเจตจำนงการใช้งานตู้รับพัสดุอัตโนมัติ โดยตัวชี้วัดได้มาจากการทบทวนวรรณกรรมและงานวิจัยที่เกี่ยวข้อง แล้วทำการเก็บข้อมูลจากกลุ่มตัวอย่างที่อาศัยอยู่ในเขตจังหวัดกรุงเทพมหานครฯ จำนวน 718 แบบสอบถามในโครงสรสร้างสมการวิเคราะห์การถดถอยเชิงเส้นพหุคูณ และ กลุ่มตัวอย่างจำนวน 500 คน ในการวิเคราะห์โครงสร้างปัจจัยเชิงสาเหตุ

ผลการศึกษาพบว่าปัจจัยที่ส่งผลต่อความน่าจะเป็นที่ใช้ทำนายการใช้งานตู้รับพัสดุอัตโนมัติได้แก่ ราคา, สถานที่ตั้ง, ระยะทาง, และปัจจัยด้านประชากรศาสตร์ (อายุ, เพศ, การศึกษา, อาชีพ และ รายได้) นอกจากนี้ในการพิจารณาปัจจัยเชิงสาเหตุที่ส่งผลต่อเจตจำนงการใช้งานพบว่าปัจจัยด้านความสามารถในการทดลองใช้งานมีผลต่อแบบจำลองการยอมรับเทคโนโลยีในด้านการรับรู้ความง่าย และการรับรู้ประโยชน์ของตู้รับพัสดุอัตโนมัติ ซึ่งมีผลเชิงบวกต่อทัศนคติ นอกจากนี้เมื่อเปรียบทียบปริมาณคาร์บอนไดออกไซด์ที่สามารถลดลงได้จากการเปลี่ยนไปใช้ตู้รับพัสดุอัตโนมัติโดยใช้อัตราการขนส่งและตัวแปรในปัจจุบันคงที่ พบว่า สามารถลดการปล่อยก๊าซคาร์บอนไดออกไซด์จากการขนส่งพัสดุได้ มากถึง 16% จากการใช้งานตู้รับพัสดุอัตโนมัติที่เพิ่มขึ้น 10%.

สาขาวิชา	การจัดการโลจิสติกส์และโซ่อุปทาน	ลายมือชื่อนิสิต .....
ปีการศึกษา	2563	ลายมือชื่อ อ.ที่ปรึกษาหลัก .....
		ลายมือชื่อ อ.ที่ปรึกษาร่วม .....

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KEYWORD: PROBABILITY PREDICTION, intention to use, automated parcel lockers, structural equation model, multiple linear regression

Orawee Thongkam : FACTORS INFLUENCING ADOPTION AND USAGE PROBABILITY OF AUTOMATED PARCEL LOCKERS. Advisor: Assoc. Prof. MANOJ LOHATEPANONT, Sc.D. Co-advisor: Assoc. Prof. PONGSA PORNCHAIWISESKUL, Ph.D.

The study proposes a model to predict probability to use Automated Parcel Locker (APL) in Bangkok by adopting Multiple Linear Regression. In addition, to help business to market to the right target and increase the intention to use, the study investigates factors influencing Intention to use APL by employing Structural Equation Model (SEM). The framework is developed based on Technology Acceptance Model (TAM) and other external factors. The questionaries were conducted for both methods with 718 observation and 500 responses, randomly selected.

The results show that variables best predict probability to use APL is price set with discount, followed by location of APL, travelling distance, and demographic factors (age, gender, education, occupation, and individual income). Moreover, from SEM analysis, it shows that Trialability has strong positive impact to Perceived Ease of use and Perceived Usefulness, which positively impact to Attitude and Intention to use respectively. However, it also found out that Transaction cost, Technology anxiety and Perceived control do not impact on Intention to use. For the last part of this study, the comparative analysis showed that if 10% of APL adoption is realized, 16% of carbon emission will be reduced based on given assumptions.

Field of Study: Logistics and Supply Chain Management — Student's Signature .....

Academic Year: 2020 — Advisor's Signature .....

Co-advisor's Signature .....

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Orawee Thongkam

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Chapter 1: Introduction

1.1 Last Mile Delivery and a rise of E-commerce

E-commerce has reshaped the worldwide market as online buying has grown in popularity as internet connection has spread to every corner of the globe. enhanced by smartphone usage, which became part of living of billions of people. E-commerce has grown dramatically in recent years, with a growing number of customers in B2C e-commerce ordering things online and having them delivered to their homes Cárdenas, Beckers, and Vanelslander (2017). From 2009, e-commerce value was $16.13 trillions and increased to $25.68 trillion in 2017 (Y. Wang, Zhang, Liu, Shen, & Lee, 2016) and in 2019, it is anticipated to reach $29 trillion (UNCTAD, 2019).

B2C e-commerce is rapidly growing phenomenon globally and the online market both in mature and emerging markets. In 2018, the global economy has been continually expanding, it has been worth more than € 2,500bn worldwide. When offline market was compared, new challenges for businesses are enabled by B2C e-commerce to manage new issues (Mangiaracina, Perego, Seghezzi, & Tumino, 2019).

New business model has large impact on last mile delivery. The innovative technology in delivery that emphasize on customer's requirement to have faster delivery such as drone delivery service and autonomous/automated ground delivery are mentioned to be a new business model. Particularly in parcel delivery, which is gaining media and corporate interest. According to a research, the global parcel delivery value is €70 billion, where 40% were from United states, China and Germany. The largest growth on parcel delivery is inevitably as a result of E-commerce, the volume was from the shift of B2B to B2C was accounted for around 7-10% (Joerss, Neuhaus, & Schröder, 2016).

In the postal industry, the revenue had reached €392.3bn in 2017, which increased by 14.3% from 2016 and parcel and logistics had grown by €9.0bn and €1.5bn respectively as a result of e-commerce (International Post Corporation, 2017). Especially in Asia-Pacific region where e-Commerce has been sharply growing and had more than 50% of the global market share (Thailand Post, 2018).

With the growth of e-commerce, consumer preferences have also raised exceptionally important in parcel-delivery market. Large e-commerce businesses and numerous start-ups both highlighted last-mile services as a crucial differentiation (Joerss et al., 2016). Thus, supply chain needs to adapt new methods that enhance the delivery to be fast, cheap, at the same time reliable. Therefore, the key success is last mile delivery, the last stage of supply chain (Gdowska, Viana, & Pedroso, 2018).

Thailand E-commerce

The largest rate of e-commerce growth is in Asia, particularly in Thailand, which has had significant growth in ASEAN. The enormous increase is due to e-Payment and fast delivery, which allows customers to shop online even easier and more conveniently. The e-commerce sector in Thailand has risen at the rate of 10.41%, 14.03% and 9.86% from 2014 to 2017 respectively as illustrated in figure 1. The value reported in 2017 was a about 2.81 trillion Baht, increased to 3.2 trillion Baht in 2018 and it is anticipated to be 4 trillion Baht in 2019 with expected rate of growth of 16.49% for 2019. While, it is projected by Euromonitor that the potential growth of Thai e-commerce business is as much as 22% annually until 2022 (ETDA, 2018).

Among E-Commerce Value reported in 2018, B2B has the largest share, 54.36%, followed by B2C, 27.47% and B2G, 18.18% as shown in figure 2 and 3 (ETDA, 2018).

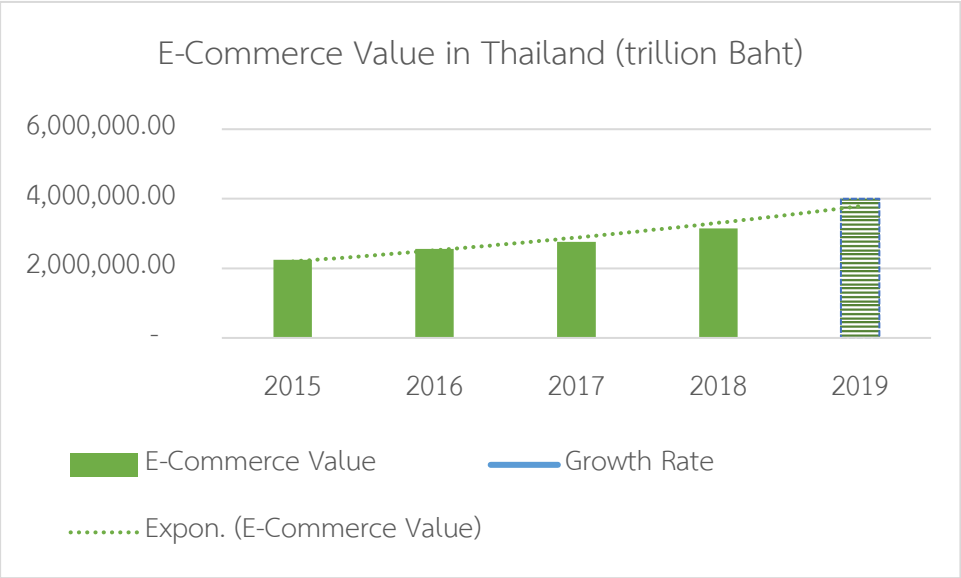

Figure 1: E-Commerce Value in Thailand (ETDA, 2018)

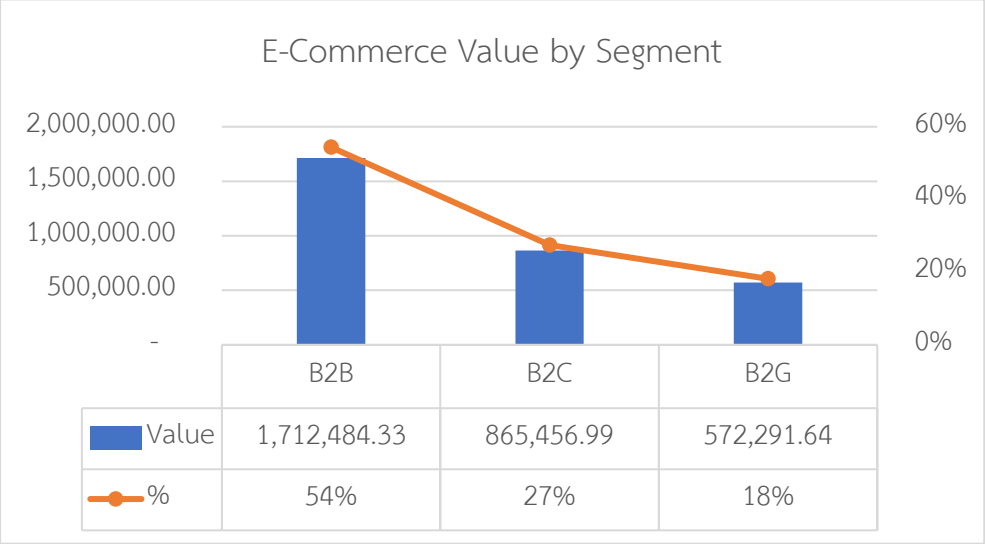

Figure 2: E-Commerce Value by Segment (ETDA, 2018)

By industry, the highest share of e-commerce is from retail and wholesale business which has 31.78% shared, followed by hospitality and production, 27% and 19% respectively. However, in Logistics related to e-commerce is also growing at the

highest growth rate as it is estimated to grow in 2018 by 20% and in average of 26% from 2015-2018.

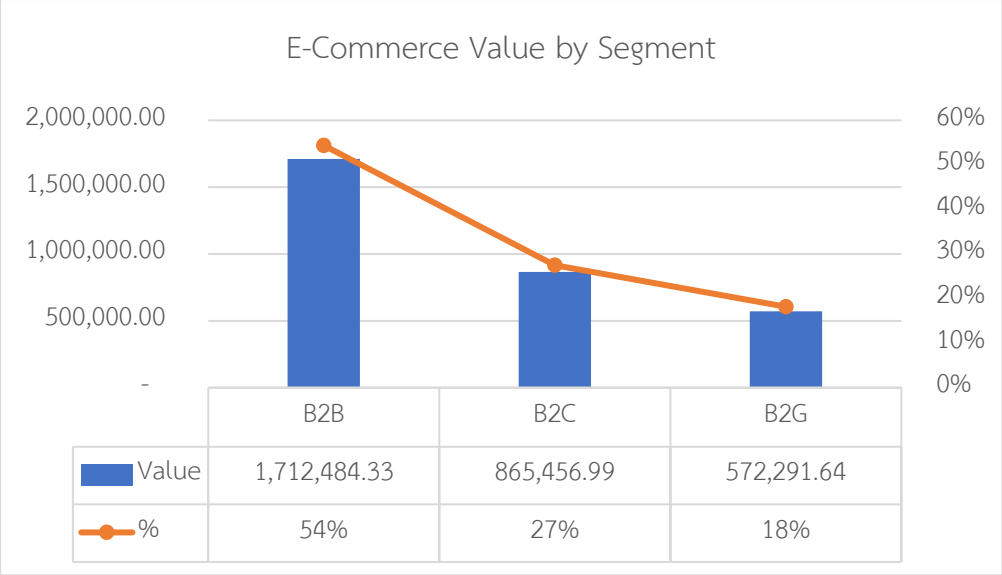

Figure 3: E-Commerce Value by Segment

Thailand E-commerce and Logistics services

As a matter of fact that E-commerce depends largely on logistics express for both small businesses (SMEs) and large enterprises. The e-commerce Value survey in Thailand showed that for large enterprise level, Third Party Outsource Providers (such as DHL, Nim Express, Kerry, FedEx) are most used, followed by Thailand post, and own Transport, 39.13%, 34.78% and 26.08% respectively. While SMEs prefer Thailand post, which is accounted for 75.25% and others for the rest. Kasikorn Research Center showed the value of logistics business, segmented by logistics activities in Thailand in 2016, 2017 and 2018, parcel delivery increases highest with growth rate of 9% in 2018 (Kasikorn Research Center, 2017). Figure 4 shows the value of Logistics activities by activities.

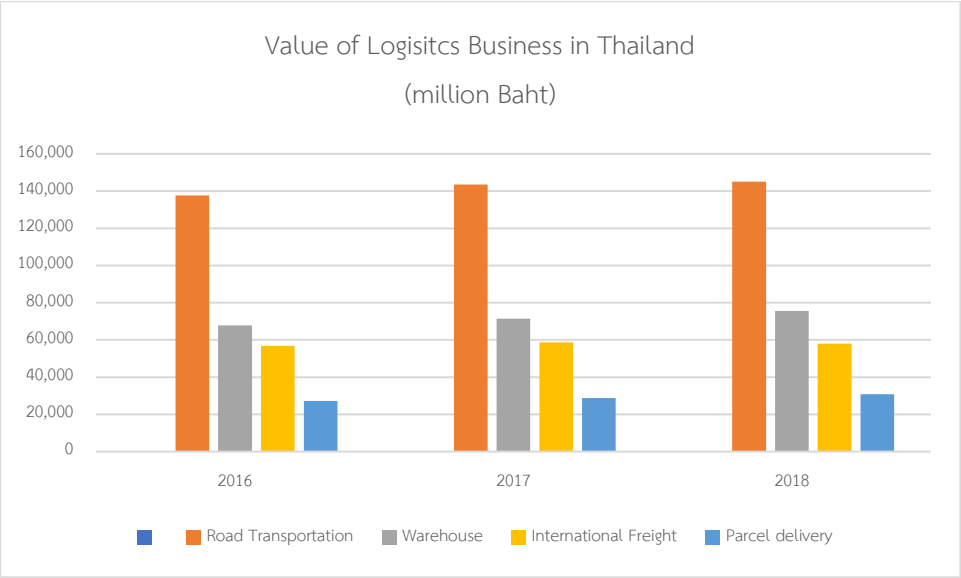

Figure 4: Value of Logistics Business in Thailand (Kasikorn Research Center, 2017)

In express services, Thailand post has highest share, with sales revenue of 27,897 million Baht in which in Bangkok is accounted for 50-55% market share and in other provinces for 75% share (Transtimenews, 2018).

With Thailand post, the revenue from postal parcels is reported as 13.47 million Baht in 2018 and overall transportation and logistics group showed a tendency of increase by 11% from the previous year as a result of higher domestic EMS service use which has been continuously increasing by 12% in comparison of 2018 (Thailand Post, 2018). The increase in volume is reported as corresponded to the growth of the domestic e-commerce as well. As anticipated, there would be parcel delivered from e-commerce market place around 350,000-400,000 pieces per day in 2018 (BLT Bangkok, 2018) and in 2019, Kerry express reached 2 million parcel deliver per day in Thailand (Kerry Express, 2019).

Last mile delivery is accepted as the most costly part. It is also highest polluting segment of the supply chain (Cárdenas et al., 2017; Edwards, McKinnon, Cherrett, McLeod, & Song, 2010; Guiffrida, 2014) as the cost of this activity is up to 55% of supply chain cost (Hübner, Kotzab, Christop, Kuhn, & Wollenburg, 2016) and It accounts for up to 55% of overall delivery expenses (Köhler & Haferkamp, 2019) and dominant contributor to environment impact is identified to be from last mile

delivery and that has a strong relationship between CO_2 emission and unsold items, which is a serious problem in traditional trading (Guiffrida, 2014).

It accounts for up to 55% of overall delivery expenses in Last mile delivery. From the transit point to the final drop location in a supply chain, a range of activities and processes are involved (Lindner, 2011). The term “last mile” has several synonyms, including “final mile”, “home delivery”, “last-mile supply chain” “grocery delivery”, and “business to consumer distribution”. The penetration point refers to an inventory location (such as fulfilment center, manufacturing site, or retail store) where customer order activates a fulfilment process. The destination point is commonly indicated by where an order is delivered. The choices could be home/ office, or pre-determined collection delivery point (CDP) (Lim & Srai, 2018).

As last-mile delivery becomes a more important source of differentiation among competitors, businesses and carriers are more likely to invest in delivery innovations including pick-up points, automated delivery stations, and parcel lockers. However, the understanding of last mile delivery design model is still limited. The key is to seek model that best fit the operations and customers’ requirements (Lim, Jin, & Srai, 2018).

A systematic literature review from Melacini, Perotti, Rasini, and Tappia (2018) identified many studies under delivery planning and execution. The main issues in Last mile logistics can be categorized into 2 areas (Mangiaracina et al., 2019). First, the research on how to make last mile delivery more efficient and cost effective based on vehicle routing problem (VRP) were conducted by many authors e.g. Geetha, Poonthalir, and Vanathi (2013); (Greasley & Assi, 2012; Reyes, Savelsbergh, & Toriello, 2017; Verlinde, Macharis, Milan, & Kin, 2014). X. Yang and Strauss (2017) conducted a study of home delivery based on approximate dynamic programing method to maximize profit. In order to manage booking horizon prior to the actual delivery, a policy to handle dynamic delivery slot pricing is taken into account. Another study used demand management and dynamic time slot allocation to maximize delivery schedule (Mackert, 2019). While Pan, Giannikas, Han, Grover-Silva, and Qiao (2017) provides a study by using electricity usage data to assess the

possibility of a client being absent, in order to enhance delivery success rates and optimize transportation.

One of the most adopted solution is to use collection-delivery points (CDP) in which customers can pick up and return their online purchase (Weltevreden, 2008), Collection- delivery point:, which the pickup service points could be located at a post office, a shop or a gas station (Iwan, Kijewska, & Lemke, 2016). Second, as home delivery causes lots of problems in sustainability issues in urban freight transport, the alternatives of home delivery are studied such as Collection Delivery Points as referred to pickup point, Click & collect, locker point, service points, drive through delivery mode (Lang & Bressolles, 2013; Punakivi & Tanskanen, 2002; Saskia, Mareï, & Blanquart, 2016; Weltevreden, 2008) which provides benefits for both retailers, carriers and customers (Gallino & Moreno, 2014). However, the delivery options depend largely on geographic situation, population density, local competition (Hübner et al., 2016) as well as customer perceptions (Goethals, Leclercq-Vandelannoitte, & Tütüncü, 2012; Hagberg & Holmberg, 2017; Moroz & Polkowski, 2016; Weltevreden, 2008). Some emphasize on effectiveness and efficiency of alternatives and develop quantitative approach to determine optimal number of parcel lockers, locations, and sizes (Deutsch & Golany, 2018; R. van Duin, Wiegmans, van Arem, & van Amstel, 2019).

The adoption of Collection-and-Delivery stations (CDP) where customers can collect and return online items is discussed as an alternative to home delivery (Weltevreden, 2008). CDP solutions are separated into pickup points (PP) and parcel lockers, (or automated parcel lockers, locker points, shared reception boxes) (Zenezini, Lagorio, Pinto, Marco, & Golini, 2018). The literature discussed CDP variations: attended and unattended (Lim et al., 2018) where attended is achieved by the development of new infrastructures, the use of existing facilities, or the formation of a partnership with a carrier. Unattended CDP, on the other hand, is established by self-contained reception boxes or parcel lookers that can be found everywhere from private houses to public locations (such as gas stations and rail stations) that are easily accessible to a large number of people. McKinnon and Tallam (2003) described that CDP involves a provision of a network of services points where they

can be attended (in which collection is done through service attendants) and unattended (in which collection is done through fully automated systems). In comparison to traditional courier services, parcel lockers significantly reduce the number of supplies and eliminate the need for drop deliveries due to the recipient's absence (Iwan et al., 2016). The distinctive advantages of parcel lockers are summarized by Torrentelle et al (2012) (cited in (Iwan et al., 2016)- Benefits of lockers are: Possibility to pick up parcel 24/7, order is informed by SMS or email , reduction in freight transport strip, and low delivery cost.

Typically, parcel lockers are located in public locations (e.g. shopping centers, railway stations or bus stations, schools and universities, etc.). As a result, goods can be received at a convenient time, frequently while doing something else, such as shopping or fueling the car.

Both services points and parcel lockers have their own strengths and weaknesses as shown in table 1.

Table 1: Strength and weakness comparison of service points and APL

Item	Service points	Parcel lockers
Operating hours	+	-
Time spent to collect parcel	+	-
Anonymity when picking up the package	+	-
Payment service	+	+
Payment alternatives	-	+
Ability to store items	-	+
Public space required	-	+
Crime and safety factors	-	+
Opportunity to do something else with parcel collection	-	+
Service ease of use	-	+

Home delivery problems and delivery alternatives

Home delivery has become a major challenge for businesses and carrier service providers, and it is a significant element of freight transportation, resulting in fragmented shipments (Xu, Ferrand, & Roberts, 2008) which incurred high service cost to serve and impact greatly on environment, in which higher emission is a consequence from cars of transport companies (Weijters, Rangarajan, Falk, & Schillewaert, 2007). More frequent home-based local deliveries, on the other hand, will certainly increase traffic congestion and environmental issues in cities, making it more difficult for carriers to meet customer requirements.

It is self-evident that cost-effective fulfillment is particularly difficult in the case of attended home deliveries if the parcel delivery business is to survive (N. Agatz, Campbell, Fleischmann, van Nunen, & Savelsbergh, 2008). Several studies are conducted to make home delivery more efficient and less impact on the environment. J. Van Duin, W. De Goffau, B. Wiegmans, L. Tavasszy, and M. Saes (2016) applied address intelligence by using historical delivery data to predict future delivery. The application of multiple linear regression techniques is used to estimate estimating redelivery potential. This shows the outcomes of using address intelligence to evaluate the possibility for redelivery reduction. Ehmke, Steinert, and Mattfeld (2012) discussed about the integration of time-dependent travel times in time-dependent vehicle routing model. The study provided time-dependent travel time data sets to achieve more reliable and cost-efficient delivery tours.

However, there are still problems from home delivery as referred to last mile issues. Park and Regan (2004) focused on the 'not-at-home-at-the-time-of-delivery' issue, which becomes a critical factor in determining the success of home delivery. When the customer is not present for delivery or the time window for delivery is not communicated prior to delivery, it results in increased operating costs for retailers or carriers as goods must be re-delivered the following day and inconvenience for customers if they must be present for delivery, which results in lower satisfaction (Gevaers, Van de Voorde, & Vanelslander, 2014; Xu et al., 2008). The failed first time delivery ranked from 12%-60% (N. A. H. Agatz, Fleischmann, & van Nunen, 2008; J. h.

r. Van Duin, Wiegmans, & Arem, 2019). The recent researches reveal the percentage of failed first time delivery to be from 3%to 50% as table 2 below:

Another problem is that, in order to make home delivery more efficient, it requires density of delivery area, as the denser the area, the higher the delivery efficiency. However, with window time limitation, make it more difficult to deliver as while carriers need longer window time for route efficiency, customers want, on the contrary, to shorten it (J. h. r. Van Duin et al., 2019).

Table 2: Failed First Time Delivery Rate

Authors	**Topic**	**Location**	**Failed first time delivery rate**
Edwards, McKinnon, and Cullinane (2009)	Carbon auditing the "last mile": Modelling the environmental impacts of conventional and online non-food shopping.	UK	2%-30%
Song, Cherrett, McLeod, and Guan (2009)	Addressing the last mile problem- the transport impacts of collection/delivery points.	UK	25%
Okholm and Thelle (2013)	E-Commerce and delivery: A study of the state of play of EU parcel markets with particular emphasis on e-commerce.	EU	3%-50%
IMRG	UK Consumer Home Delivery Review	UK	13%-14%

Authors	Topic	Location	Failed first time delivery rate
J. H. R. van Duin, W. de Goffau, B. Wiegmans, L. A. Tavasszy, and M. Saes (2016)	Improving home delivery efficiency by using principles of address intelligence for B2C deliveries	The Netherlands	25%
Goodchild and Ivanov (2017)	The final 50 feet of the urban goods delivery system	US	10%-15%

Unattended delivery may provide different options to the 'not at home' and 'uneven time slots' problem. Many solutions are proposed for these challenges mentioned earlier (Gevaers, Voorde, & Vanelslander, 2009), solutions including for instance, personal reception boxes and in car delivery, which increases first time delivery success (van Loon, Deketele, Dewaele, McKinnon, & Rutherford, 2015). Smart lock systems are touted as a viable option since they give delivery couriers access to your home via specialized digital keys, even if no one is home to accept the package (Buldeo Rai, Verlinde, & Macharis, 2019). Moreover, consolidation is done to combine efficient routing program. One way of consolidation is to have parcel pick-up points and lockers points that are located in dense area such as busy area and residential areas. It also reduces the negative environmental impact of parcel delivery (Xiao, Wang, Lenzer, & Sun, 2017).

1.2 Research Gap

Several studies were conducted to investigate and examine the impact of Collection -Delivery Points (CDP) on both economic and environmental aspects

(Anand, Quak, van Duin, & Tavasszy, 2012; Deutsch & Golany, 2018; Durand & Gonzalez-Féliu, 2015; McLeod, Cherrett, & Song, 2006; Punakivi & Tanskanen, 2002). Those works relate to automated parcel lockers (APL) are still limited (Lachapelle, Burke, Brotherton, & Leung, 2018), Despite the fact that there are certain qualitative works, such as surveys, targeted at evaluating users' intentions to use (Buldeo Rai et al., 2019; Kedia, Kusumastuti, & Nicholson, 2017; Xueqin Wang, Wong, Teo, Yuen, & Li, 2019; Xueqin Wang, Yuen, Wong, & Teo, 2018; Yuen, Wang, Ng, & Wong, 2018). Those qualitative works are less due to the reason of the study is with specific contribution from limited number of industries (mainly in groceries), geographical scope (mainly in Europe), and from few managerial perspectives from retailers and carriers, in which the scarce awareness of saving and impacts that this alternative delivery could brought up as this field of the study is more recent and less investigated with contributions that flourished only in the last years (Slabinac, 2015). Thus, this study will provide comprehensive aspect of probability prediction of APL adoption.

1.3 Research Questions and objectives

The aim of the study is to investigate the probability of Automated parcel locker (APL) adoption in Bangkok, Thailand. The study is aimed to develop a model to predict the probability of APL adoption using several related factors from previous studies. What is the probability of potential Demand of adoption of APL in Bangkok? To answer the followings:

- To identify the predictors of APL Probability to use in Bangkok , Thailand
- To what extent, socio-demographic, behavioral factors and preferences factors explain the probability of using APL.

The result of the study provides important factors that explain probability to use APL. Moreover, after assessing probability, the next question is how to increase those probability to increase market share of APL, another study is conducted to determine factors influencing APL intention to use in Bangkok. The study is based on Technology of Acceptance model (TAM) and related factors from literature review

and previous studies, including Perceived control, Transaction cost, and Technology anxiety. The research question for this study is

- which factors have significant impact on Intention to use APL
- To what extent, factors identified from literature reviews have impact on Intention to use APL

The last objective of this study is to estimate the reduction in carbon emission from APL adoption as alternative to home delivery, comparing to home delivery with current failure delivery rate. Thus, the research question for this study is

- To what extent, carbon emission reduction can be achieved from adopting APL together with home delivery, compared to traditional home delivery.

1.4 Scope of work

The exploratory research focuses on Bangkok, Thailand adoption of automated parcel lockers. the sample were taken from people who are living in Bangkok, and experience shopping online at least once in the past 3 months. The age of the sample is between 15-60 years old, due to the capability to travel and flexibility of using Internet to shop online.

1.5 Research Contributions

As parcel lockers represent a growing alternative to home delivery, the contribution of this study is three folds in accordance to sustainability in both managerial and academic implications. First, business guidelines to locate locker parcel where customers are willing to use especially in Thailand context, is rare. Cost reduction is the main contributor for both business and customers which could lead to more than 80% total cost saving from both business and customers side (Giuffrida, Mangiaracina, & Tumino, 2012). While home delivery failure rate tends to decrease, it offers more convenience to customers in the aspect of waiting time reduction and cost of picking up at the postal centers or depots. It also reveals Thai customer preference on Parcel Lockers, which allows the business to understand the

influential factors impact the use. Second, from a societal and environmental standpoint, the adoption of parcel lockers enables shipment consolidation, significantly reducing the number of delivery tours required for freight mobility. This reduction results in decreased road congestion and curb-side parking demand (Q. Chen, Conway, & Cheng, 2017; J. H. R. van Duin et al., 2016). The impact from parcel lockers is showed to gain awareness of environmental problems, such as emission, PM2.5 and PM10 related to urban distribution as the trips and numbers of vehicles as well as congestion are decreased due to the decrease in road occupancy. As academic contribution, the studies of parcel lockers are limited in Asia, especially in Thailand, which this study is the first study on the factors influencing the use and the impact of parcel locker implementation.

Chapter 2: Literature review

This purpose of this chapter are to demonstrate previous research literature in the field of APL and related literatures. Several tools used for in this field are reviewed. This chapter is divided into 4 sections: first is APL impact on Economic and Environmental aspect, second is the review of predictors of APL adoption. Third, Factors influencing Intention to use APL is reviewed. And Last, tools and methodology used in APL and related fields are reviewed.

2.1 Impact of Delivery Alternative and factors influencing an adoption

2.1.1 Economic impact of the adoption

As E-commerce (B2C) drives up the social and environmental costs of products delivery, there are both opportunities and problems for enhancing the sustainability of urban freight systems. As the B2C e-commerce sector expands, the importance of last-mile deliveries in urban areas grows, as a result demand of last mile delivery is growing, consequently, there are increasing in congestion and traffic problems. The impacts of alternative home delivery are investigated a lot both from business perspectives, customer perspectives and environmental sustainability perspectives.

One of the five best strategies to handle the last-mile delivery problem is to use CDP and considered as the effective solution of missed home delivery problem. Automated parcel lockers (APL) and self-collection point/ pickup point (PP) become fast-growing solutions. APL and PP deliveries are shown to be less cost than house deliveries. These options are supplied by online companies as well as carriers and transport providers, and they combine the needs of consumers for flexibility in delivery as well as the needs of businesses to maximize parcel distribution through shipment aggregation (Morganti, Seidel, Blanquart, Dablanc, & Lenz, 2014). A literature review from Slabinac (2015) reveals that APL and Pickup points are identified as last mile innovative solution to increase delivery efficiency, in which both of solutions impact cost drivers of the delivery activity by decreasing cost of failed delivery, and increasing customer density, delivery automation.

Other than mentioned above advantages, customers and drivers benefit since it is less expensive to group customer zones to deliver faster, safer, and more secure because there is no likelihood of delivery failure. The point of view of the carriers are identified that CDP is the way to optimize vehicle routing problem and reduce total delivery time (Zenezini et al., 2018). Xuping Wang, Zhan, Ruan, and Zhang (2014) conducted a study on total cost of different delivery modes using VPR model and genetic algorithm. The results show that CDP is superiors in many aspects included the operation efficiency in terms of total time and total cost, comparing to home delivery, total distance is less by 70%, the number of vehicles used is less. The recommendation is made that CDP becomes the most economical way when orders are massive.

Gevaers et al. (2014) conducted a scenario on different delivery options. The study compares total cost of each delivery scenarios proving efficiency from extending time window, convincing customer to choose working place as delivery points, using CDP and executing cargo bikes instead of van or trucks. The results show the reduction in total cost of last mile, where the longer the time window, the lower the total cost of delivery. The scenario to convince customer to choose to receive the parcel at the office increase first time hit rate of the delivery, thus, the delivery cost reduces significantly. The reduction in cost is from the combination of increasing in first time delivery success and delivery density and the cost dropped by 29%. The use of CDP scenario shows largest impact on total cost of last mile, in which first time delivery success is assumed to be 100%. This implies that more parcels can be dropped at one CDP, as a result, the cost can be further dropped by more than 50% on average of 2.5 parcels per CDP.

Xuping Wang et al. (2014) investigated the competitiveness of home delivery, reception box, and CDP as last-mile delivery options. The study shows that CDP is appropriate to the scenario where population density is high and there is large order quantity. With the conditions stated, total time and total cost are lowest.

From a customer perspective, they generally feel that CDP is attractive due to its convenient on various aspects of advantages such as no missed delivery, service extensiveness, easier return and longer pick up window time (Iwan et al, 2016). With

appropriate location of APL, it provides significant benefits not only economic aspect, but also environmental aspect as this solution takes advantages of consolidating deliveries and they are independent from available time slot from both business and customers' requirements (Iwan et al., 2016).

From the business perspective, by using parcel locker, delivery cost is lowest, compared to home delivery and other alternatives (Punakivi, Yrjölä, & Holmström, 2001). The study from Punakivi & Tanskanen (2002) show that by using parcel lockers can save delivery cost from 55% to 66% and operating efficiency is 2.8 times higher compared to home delivery. The comparison from Allen et al., (2007) showed that Drop off time is very short comparing to other alternatives as well as failed delivery is virtually none. Similarly, the operational costs is compared between homed delivery and parcel locker, which shows reduction from 2.024 /parcel to 0.245 / parcel in urban case, and from 4.895 / parcel to 0.363 / parcel in extra urban case (Giuffrida et al., 2012).

Lemke, Iwan, & Korczak (2016) conducted a study on usability of parcel lockers. As a result, parcel locker adoption is increasing steadily, particularly in European countries, as they help reduce traffic and maximize the use of cargo compartments by consolidating deliveries and making them more independent of available time slots (Giuffrida et al., 2012; Gonzalez-Feliu, Ambrosini, & Routhier, 2012; Iwan et al., 2016; Lemke, Iwan, & Korczak, 2016; Morganti, Seidel, et al., 2014) where the rapid development are in Germany, Poland, Netherland and France (Iwan et al., 2016). The study from Iwan et al (2016) compare the use of parcel lockers of InPost, Poland and Home delivery. The analysis shows that the number of kilometers travelled during a day of parcel lockers is less by 50%, the number of parcels delivered during a day is 10 times higher, CO_2 emission is less by 95%, and annual fuel consumption in liters is significantly decreases from approximately 2 million liters to approximately 1 million liters. Gonzalez-feliu et al (2012) anticipated positive outcome in terms of lower operating costs and emissions. The simulation is conducted to compare travelled distance between traditional shopping and alternative deliveries (Drive through, home delivery and pickup point). The 3 scenarios are set: extreme adoption (only 1 delivery method adoption), realistic

adoption of traditional shopping and one alternative delivery, and realistic adoption of traditional shopping and 2 alternative deliveries. In extreme adoption, customers will use only one channel to either go shopping or get parcel delivered. Due to the use of small vehicles and delivery conditions (B2B flows rather than B2C), CDP has proven to be the most optimal of the others, resulting in a significant reduction in total kilometers traveled. On the other hand, the most promising optimization is realistic with 2 good combination of delivery alternatives which shows the reduction in travelled distance by 13% (Gonzalez-Feliu et al., 2012).

An analysis from Morganti et al. (2014) provide a comparison of the presence of CDP in France and Germany, Packstation in Germany, ByBox in France, and Cityssimo in Germany are the three primary APL providers. The Packstation network operated by DHL/Deutsche Post in Germany is the largest APS network (with 2,500 locations around the country). However, comparing PP, there are just a few APL networks in France mainly as a result of security regulations. However, carriers can enhance the amount of first-time deliveries, streamline delivery rounds, and minimize operating costs by concentrating deliveries to CDP.

2.1.2 Environmental Impact of the adoption

As there are lots of urban transportation issues where cities experience traffic problems can lead dangerous situation and fatal accidents like congestion and pollution, such as CO_2, NOx, PM10, and SO2 created as a result of increasing in last mile delivery (Spijkerman, 2016) , many studies are conducted to assess the impact of implementing CDP in such a way that to sustain a livable city. The majority of research evaluate the effects of home delivery options based on distance driven energy use and externalities (P. van Loon, A. C. McKinnon, L. Deketele, & J. Dewaele, 2014). Song, Guan, Cherrett, and Li (2013) found that using local collection and delivery points instead of standard carrier redelivery techniques for failed first-time home shopping deliveries can drastically reduce greenhouse gas emissions. Some use CDP as an alternative of firm's depot from failed deliveries, which means that instead of returning parcel to depot and requesting customers to pick up, CDP nearby customer's place is used to pass the parcel for customers to pick up. The great majority of emissions from a traditional failed delivery are caused by personal travel

associated with the client retrieving a missed redelivery from the carrier's local depot, which accounts for 85% to 95% of emissions. The results show that CDP offers significant CO_2 reductions as consumers travel less distance on average to collect failed home delivery by 13%-47%. The variation of CO_2 depends on locations where CDP presence, in which the CDP at supermarket generates greatest CO_2 per drop, while CDP at post office generates least CO_2 per drop due to its large scale of network (Edwards, McKinnon, Cherrett, McLeod, & Song, 2009). Similarly, in 2009, the Flanders Institute published a research for Logistics that found that switching from house deliveries to delivery to a CDP can save CO2 emissions by 60% [cited in (van Loon et al., 2014)]. Additionally, the delivery van's journey was cut in half, and slightly more than half of clients were able to pick up their shipment during a trip to another location without having to travel additional kilometers (van Loon et al., 2014). An estimation of customer's mobility behaviors changes by using APL from Hofer, Flucher, Fellendorf, Schadler, and Hafner (2019) found that there is a potential for a 27% reduction in emissions and vehicle kilometers per pickup or dropped parcel. Moreover, the study also reveals that if the distance is less than 1.9 km, customers also shows their willingness to use environmentally friendly transport modes to pick up their parcels, while 3.6 km is the acceptable distance to go pick up their parcels by car. However, the variation of relative carbon intensity largely depends on delivery failure rate, distance between customer's place and CDP, the level of trip chaining, and the consumers modes of transport (McLeod et al., 2006) and dense network of CDP (Song et al., 2009). The scenario comparing home delivery and CDP is compare from travelled distance, road occupancy and GHG emission. CDP shows most favorable results as 1.4% - 9%, in accordance with the adoption rate (Durand & Gonzalez-Féliu, 2015). A comparison of home delivery and locker points are done by Carotenuto et al. (2018) on the basis of travelling distance, time spent, and finally evaluate CO_2. The results show that the scenario with using locker, distance, and time decrease. Moreover, CO_2 emission decrease by more than 21%. Table 3 summarizes impacts of alternative delivery both from economics and environmental aspect.

Table 3: Summary of Economic and Environmental Impacts

Topic	Authors	Aspect	Methods
Home Delivery vs Parcel Lockers: an economic and environmental assessment	Giuffrida et al., 2012	Economic and Environmental	Mathematical modelling
The impact of e-commerce on final deliveries: alternative parcel delivery services in France and Germany	Morganti et al., 2014	Economics	Content analysis
Innovative solutions to increase last-mile delivery efficiency in B2C e-commerce: a literature review	Slabinac, 2015	Economics	Literature review
Usability of the parcel lockers from the customer perspective – the research in Polish Cities	Lemke et al., 2016	Economics	Content analysis
Analysis of parcel lockers' efficiency as the last mile delivery solution – the results of the research in Poland	Iwan et al., 2016	Economics	Content analysis
Flexible parcel delivery to automated parcel lockers: models, solution methods and analysis	(Orenstein, Raviv, & Sadan, 2019)	Economics	VRP
Estimation of changes in customer's mobility behaviors by the use of parcel lockers	Hofer et al., 2019	Environment	Panel survey
Transport impacts of local collection/delivery points	McLeod, Cherrett, & Song, 2006	Economics	VRP
Topic	**Authors**	**Aspect**	**Methods**

The impact of failed home deliveries on carbon emissions: Are collection/delivery points environmentally friendly alternatives?	Edwards, McKinnon, Cherrett, McLeod, & Song, 2009	Environment	Quantitative analysis
The growth of online retailing: a review of its carbon impacts	P. Van Loon, A. McKinnon, L. Deketele, and J. Dewaele (2014)	Environment	Literature review
New trends on urban goods movement: Modelling and simulation of e-commerce distribution	Gonzalez-Feliu et al., 2012	Economics	Mathematical modelling
How to choose “last mile” delivery modes for e-fulfillment	Wang et al., 2014	Economics	VRP, Simulation
Impacts of Proximity Deliveries on e-Grocery Trips	Durand & Gonzalez-Féliu, 2015	Environment	Simulation
Fashion consumer behavior impact on the model of last mile urban area emissions	Spijkerman, 2016	Environment	Mathematical modelling
Comparison of various urban distribution systems supporting e-commerce. Point-to-Point vs collection – point based deliveries	Carotenuto et al., 2018	Environment	VRP

2.2 Predictors of Customers' adoption of Automated Parcel Lockers (APL)

Notwithstanding receiving substantial attention in the business environment, research in parcel lockers appears to be scared and limited. Despite the fact that it has been discussed in numerous studies, no scholarly attention has been paid to this service technology in those studies (Ducret, 2014; Mangiaracina, Marchet, Perotti, & Tumino, 2015; Morganti, Dablanc, & Fortin, 2014; Weltevreden, 2008).

Appointed specifically to CDP, customer's acceptance and factors influencing those acceptance are studied in several countries such China (Weijters et al., 2007), Netherlands (Weltevreden, 2008), France, Germany (Morganti, Dablanc, et al., 2014; Morganti, Seidel, et al., 2014), Poland (Efthymiou & Antoniou, 2016; Lemke et al., 2016), Sweden (Vakulenko, Hellström, & Hjort, 2018), New Zealand (Kedia et al., 2017), Singapore (Efthymiou & Antoniou, 2016), and Australia (Lachapelle, Burke, Brotherton, & Leung, 2018). Since local conditions are different from countries to countries, the success of CDP also vary. For instance, in car dominant city, the rate of using internet is high and this is considered impacting customer's shipping behavior. In addition, factors determining the use of CDP in many countries are dissimilar. Those factors are such as number of people working in the post office, Population density, number of post office nationwide, and cars per capita (Kedia et al., 2017).

The important roles to attract customers to use are observed to be distance and location (Lemke et al., 2016; Morganti, Dablanc, et al., 2014). The transportation nodes such as railway station, intersection, and interchange station, and most densely populated areas are expected to have CDPs. In urban area. The average accessibility to the nearest pickup points by customers in urban and rural areas are reported to be 1.6 km and 6 km respectively (Morganti, Seidel, et al., 2014). Currently, 90% of the population in Germany is within 10 minutes of a pickup station. Currently, an average pickup site has roughly 76 lockers installed; however, the number of lockers installed varies by location. Majority of the stations are sited in urban areas (Morganti, Seidel, et al., 2014). The time it takes to get CDP in the Netherlands varies according on the service provider. More than half of consumers claim to be able to reach pickup places within 5 to 10 minutes, depending on the provider (Weltevreden, 2008). However, according to another study, each network

enables customers to reach the service point by car in between 4 and 8 minutes in urban areas and between four and eight minutes in rural areas (Morganti, Dablanc et al., 2014). It is necessary to maximize location accessibility for potential customers as to gain efficiency and achieve sustainability to CDP network. Therefore, the location that are considered suitable location for CDPs are those located near workplace or customers living area such as gas stations, supermarkets, post offices and public transport stations (Junjie & Min, 2013; Kedia et al., 2017).

Most of self-collection points are near railway stations. Among those locations, the distance that those stations are located are around 400m and 600m from the stations and in regional railway station, respectively. This helps to increase the opportunities for customer to pickup their parcels in their commute when the stations are located and can be access easily from the public transport terminals and main road (Kedia et al., 2017). These self-collection locations can help to decrease travelling kilometers. Moreover, when CDPs are near the customer's living area or working place, it is even more beneficial as customers tend to use environmentally friendly vehicles or modes to collect the parcel (McLeod, Cherrett, & Song, 2006).

It was identified in Kedia et al. (2017) that network density, parking availability, and spatial location on CDP are determinants of CDP customers' acceptance. Achieving a successful CDP is possible if a CDP is located close to a working place or customers' places, as well as devoting consideration to security and extending operating hours. whilst Morganti, Dablanc, et al. (2014) reported that a successful CDP is a location that is near a railway station or a major transportation terminal.

Sociodemographic factors are identified as significant determinants in customer acceptance also. Gender is said to influence intention to use in a study from J. W. Weltevreden & Rotem-Mindali, (2009), in which female tends to use CDP more than male and medium education level tends to use pickup points. Moreover, from behavioral perspective, experience with online shopping influenced the use of pickup points as well. In addition, intention to use this self-collection point is influenced by frequency of online shopping, number of years purchasing online and experiencing home delivery alternatives, the household working hours and 5 minutes traveling distance by car to CDP (Morganti, Dablanc, et al., 2014). Population density

is one of the variables that shown in demographic perspective, other than that, there are variables such as employment rate, Internet access, computer ownership, and level of use (Madlberger & Sester, 2005). However, “being employed” have no significant impact on choices of delivery mode, those need products delivered in the evening. Moreover, they prefer less pickup point than unemployed status or under education. Additional delivery options also affect product types, where parcel lockers are commonly used for apparels and books, while computers are frequently collected in-store.

Several studies have shown that home deliveries are still preferred by the majority of customers, comparing to CDPs (Morganti, Dablanc, et al., 2014; Yuen et al., 2018). However, various countries have different adoption rates, which range from 5.5 percent to roughly 18%, Where 5.5% in Singapore (Yuen et al., 2018), 10% in Germany (Morganti, Seidel, et al., 2014), 18.5% of customers who shop online in Netherlands experience using APL (Weltevreden, 2008) and Parcel locker service increased by 146% in 2017, in Australia (Lachapelle et al., 2018).

Similar research has been done on grocery pickup. A semi structured interview from Vyt, Jara, and Cliquet (2017) related customer value and pickup points. The grocery pickup is defined either in store, or dedicated place nearly any store in the same chain. In depth interview with retail grocer industries provides framework for customers benefit in adopting grocery pickup are functional, experiential and relational benefits. They found that experiential benefits are key factors. The major contributions are ease of use and intuitive navigation. Website design and layouts play a key role in the success of pickup points. In addition, physical pickup points are essential to sustain customers’ confidence towards them.

Jara, Vyt, Mevel, Morvan, and Morvan (2018) provides customer benefit from grocery pickup by conducting quantitative survey. The framework proposes that there are 3 benefits gained from this service: namely functional benefits, relational benefits and experiential benefits. There are 3 types of grocery pickup included in the study: Drive-out (solitary pickup points, isolated from any store where only warehouse serves as collection point), Drive-in (the pickup points near stores and orders are picked from specific click and collect warehouse), and In-store (integrated pickup

point within the store where orders are picked from the shelf). Different significance shows in each model, however 4 variables standout are customer' relation, website, pickup point and service. The pickup points appear to be the most important to CDP success are those providing ease of access, easy authentication, waiting time, time between placing an order and availability, and scheduling amplitude.

A study in New Zealand by Kedia et al. (2017) was conducted aim to pinpoint CDP customers' acceptance issues. The results from customers' acceptance showed that customers prefer using CDP as a mean to track down undeliverable parcels. Other than that, incentive play significant role to encourage customer to use the service, which are discount or different pricing from delivery channels. Apart from the foregoing, a significant factor influencing adoption in suburban areas is CDP density, which is different from J. W. Weltevreden & Rotem-Mindali (2009) that in dense area, particularly in the CBD, more pickup points are used. Moreover, Parking availability and spatial location in suburban area make CDP is more attractive to use. This is in contrary to McLeod et al. (2006) which showed that CDPs are preferred to be located in the central business district and close to the customers' home or office. In addition, safe and secure place are concerned to be collection points like fuel station. Lastly, as some customers are unable to pick up during weekdays, hours of operation is significant to adoption.

Specifically, to APL context, it is meaningful to include customers opinion in value creation process as it appoints business and customers new opportunities. This also benefits in terms of delivery cost, customization, service times, satisfaction and loyalty (Alcock & Millard, 2006). Vakulenko et al. (2018) provides knowledge about the customer's view on adopting APL in Sweden. A study finding served as the foundation for developing the propositions and provided insight into the process of creating customer value in the context of e-commerce self-service last mile delivery. The four 4 of value created through parcel lockers are functional value, social value, emotional value and financial value.

2.3 Factors Influencing Intentions to Use APL

Though socio-demographic factors are common on the influence of the adoption such as age, gender and income (Y.-H. Lee, Hsieh, & Hsu, 2011; Proença & Antonia Rodrigues, 2011), there are psychological behavior theory research shows essential result of the intention to use. Those factors are such as, technology anxiety (Oyedele & Simpson, 2007) technology innovativeness and need for interaction play important roles. Attitudes are significant to intention to use as well, (Curran, Meuter, & Surprenant, 2003) reveal that some mention of attribute of technology itself impact on customer intention to use. Technology readiness (TR), which refers to people's proclivity to embrace and use new technologies in their personal and professional lives, is critical to customer behavioral intention, in which TR significantly improves perceived usefulness, perceived ease of use, attitude toward use, and intention to use (Lin & Chang, 2011) and TR influences perceived SST service quality and behavioral intentions.

Logistics service providers are investigating and implementing novel tools, such as self-service technologies (SSTs), as a mean to deal with the increasing volumes of delivered and returned parcels, as well as an increasing customer expectations, and toughening market competition. In the context of last mile delivery, SSTs are frequently used in the form of parcel lockers for the self-service collection and return of online transactions. Several terms are used interchangeably such as like parcel kiosks, locker boxes, automated lockers, self-service delivery lockers, and intelligent lockers (Vakulenko et al., 2018).

Under SSTs, various studies are conducted on customer's acceptance in different innovation such as self-service checkouts, mobile service, banking self-service, web-based self-service, AI, and automated vehicles (De Luca & Di Pace, 2014; H.-J. Lee, Jeong Cho, Xu, & Fairhurst, 2010; Lu, Chou, & Ling, 2009; Oyedele & Simpson, 2007; Proença & Antonia Rodrigues, 2011; Y. S. Wang, Lin, & Luarn, 2006; Weijters et al., 2007; Yuen et al., 2018). Most of the papers use innovation theory-based model such as Technology Acceptance Model (TAM), Innovation Diffusion Technology (IDT), Diffusion of Innovation (DOI) and technology planned behavior (TPB).

The influence factors of APL adoption is also broadly studied in alternative deliveries. Many researchers have studied the influential factors on customers' intention to use and try to investigate and understand the reasons why customers are willing to use it. In practice, SST is often used in business these days. The attention is given to these technological tools from both academic and business community. Generally, cost savings and shorter service time (Matthew L Meuter, Bitner, Ostrom, & Brown, 2005), location convenience (Kauffman & Lally, 1994), service efficiency, and enjoyment are gained from adopting SSTs (Bitner, Ostrom, & Meuter, 2002).

Trialability (TRIAL)

In addition, Yuen et al. (2018) provides theoretical framework to examine consumers' decision to adopt using CDP. The framework is based on Innovation Diffusion theory (IDT) indicating 5 factors influencing customers' intention; which are relative advantage, compatibility, complexity, trial ability and observability. Among 5 variable, relative advantage and compatibility are significant positive influence on customers' intention to use, in which, trialability has lower significant positive relationship. In contrast to complexity, it has a negative influence on customer's intention and observability on customers' intention is insignificant.

As the long-term viability of APL depends on the consumers' acceptance of such concept. De Luca and Di Pace (2014) conducted behavioral study in Singapore on customer's adoption perceptions on APL, combing innovation diffusion theory (DOI) and attitude theory (TRA). The attributes of innovation are classified into 2 types; first the attribute from innovation itself which are compatibility, complexity, observability, and trialability, which are related to attitude to initially adopt APL. Second, the attribute that is from the perception toward innovation, which is relative advantage from APL is perceived to be better than conventional home delivery. The study found that complexity, compatibility, and trainability have strong impact on favorable attitude towards APL adoption intention. This is emphasized that, though all of the 3 mentioned earlier have indirect relationship intention to adopt APL, but a positive attitude towards APS adoption is a good predictor of customer intention to

use. Whereas relative advantage has a direct positive impact on intention to use APL. In China, an investigation of customer's intention to use APL is concluded that the effect of privacy security, reliability and convenience on customer's intention are mediated by perceived value and transactional costs (Weijters et al., 2007). Whereas Zhou et al. (2020) investigated the impact of psychological factors on online consumers' behavior intention to adopt APL in China. The results revealed that performance expectancy, social influence, effort expectancy, and facilitating conditions are positively influence intention to use. On the contrary, perceived risk is negatively impact to the intention. Demographic groups are also varied in behavioral intention.

In Singapore, a research conducted by X. Wang, Wong, Teo, Yuen, & Li (2019) on service conveniences in self-collection investigated on service attribute in 5 dimensions access convenience (short travelling distance, 24/7 operating hours), benefit convenience (short waiting time, along the way, small parcel size), transaction convenience (easy retrieval process, flexible payment, consolidated delivery), post-benefit convenience (easy return, customer support). The finding shows that 24/7 operating hours, short waiting time, along the way, easy retrieval process and easy return impacts significantly on customers' (dis)satisfaction. Furthermore, easy retrieval process is the most sensitive attribute which suggest the priority of service providers to improve. However, the prioritization is on short waiting time and easy return to enhance service convenience (Wang, Wong, Teo, Yuen, & Li, 2019). Table 3 summarize factors impact an adoption from APL and related fields.

Numerous studies indicate that if a user is given the opportunity to try a new technology, this reduces the user's fear of the technology's use by customers (Al-Ajam & Nor, 2013; Barua, Aimin, & Hongyi, 2018; Nor, Shanab, & Pearson, 2008). From the analysis, trialability can be used as a strategic tool, to help the participants through the different stages of the behaviors change process (Strömberg, Rexfelt, Karlsson, & Sochor, 2016). However, a study of intention to use APL from Xueqin Wang et al. (2018) showed that while the trialability of an automated parcel station is perceived as an attractive feature for consumers' attitudes toward the system, it is not strong enough to elicit consumers' adoption intention. Many studies have tested

empirically in understanding the relation between trialability and the intention to use the technology (Petschnig, Heidenreich, & Spieth, 2014), trialability was found to have a positive effect on the intention to use the technology. Additionally, trialability has a positive effect on perceived usefulness and perceived ease of use (Y.-H. Lee et al., 2011). It concluded that the higher users perceive trialability, the higher the level of the usefulness and ease of use (M. Yang, 2007).

Technology Acceptance Model (TAM)

Technology Acceptance Model (TAM) is widely used in technological adoption context, for examining the acceptance, in which, this give a high degree of prediction power regarding to technology use (C.-F. Chen & Chao, 2011). The most important factors to explain the use are perceived east of use and perceived usefulness. The wide application of importance and application of TAM have been examined in many studies (Blut, Wang, & Schoefer, 2016; C.-F. Chen, 2019; C.-F. Chen & Chao, 2011; Demoulin Nathalie & Djelassi, 2016; Y.-H. Lee et al., 2011; Moták et al., 2017; Xueqin Wang et al., 2018). Lu et al. (2009) used TAM and add external stimuli, perceived service quality of kiosk. The study was conducted in Taiwan in airline business, and the findings indicated that attitude and external factors best explain customers' behavioral intentions to use kiosks, while perceived ease of use and perceived usefulness have a negligible effect on their intentions. Y. S. Wang et al. (2006) integrated TAM and TPB to predict customers' intention to use mobile service as well as added perceived credibility, which represented trust related variable and two resource-related variables which are perceive financial resources and self-efficacy to the TAM structure. And the results showed strongly support to customer intention prediction. From the psycho-socio perspective, a study on behavioral theories is conducted by X. Wang, Yuen, Wong, & Teo (2019) to explore customer cognitions and affects which explain how customers think and how they feel when using APL. Cognitive service attributes are convenience, functionality, design and security, where affects consist of address expectations (convenience, fun, design, security), feel (enjoy, assurance, customized) which all impact intention to use. When faced with choice of using SST, customers are likely to emphasize on the potential

benefits that the SST offers (Weijters et al., 2007) and in retail business context, the usefulness is identified to be main driver of the attitude toward an SST. The literature review on individuals using technology also disclose the ease which users can use the technology which affects positively their attitude toward SST (Weijters et al., 2007).

Perceived control (PC)

Theory of planned behavior (TPB) is used to examine the factors influenced customer intention in many areas: transport mode use, SST intention to use and specifically to parcel lockers (C.-F. Chen & Chao, 2011; Moták et al., 2017; Nordfjærn, Şimşekoğlu, & Rundmo, 2014; Yuen, Wang, Ma, & Wong, 2019; Zailani, Iranmanesh, Masron, & Chan, 2016; Zoellick, Kuhlmey, Schenk, Schindel, & Blüher, 2019). According to TPB, future actions are guided by behavioral intention, which argues that loyalty can be defined as a repeat purchase or frequent revisiting of a specific service or product in the future (Oliver, 1999). The primary components are composed of attitudes, subjective norms and perceived behavioral control, intention, and behavior (C.-F. Chen & Chao, 2011). Barua et al. (2018) conducted a study and revealed that a strong determinant to adopt SST is perceived control. This is an expression of an individual's confidence in his or her ability to command technology in order to obtain the desired result. Numerous studies showed that control is significant factor and the more control over SST, the more the use of SST (Barua et al., 2018; Bowen, 1986; Demoulin Nathalie & Djelassi, 2016).

Technology anxiety (TA)

Technology anxiety is a significant factor influencing customers decision to engage, adopt and try on new technology (Venkatesh, Morris, Davis, & Davis, 2003). The term "technology anxiety" refers to the degree of anxiety felt by an individual when faced with the decision to use a technology or innovation (Igbaria & Parasuraman, 1989). The relationship between anxiety and use or intention to use has been investigated, and it has been discovered that higher levels of anxiety are associated with lower levels of use (Demoulin & Djelassi, 2016; Jia, Wang, Ge, Shi, &

Yao, 2012; Matthew L Meuter et al., 2005; Oyedele & Simpson, 2007) . C.-F. Chen, White, and Hsieh (2020) also stated that technology anxiety has a strong negative impact on intention to use APL. Moreover, it is reported that younger consumers reduced the effects of TA but for older consumers, promotions and communications can be the strategies to encourage the intention to use. The study from (Igbaria & Parasuraman, 1989) also reported that technology anxiety is significant different in student group in which they are more familiar with technology.

Transaction cost

Transaction cost is significant factor for users considering whether to use SST, in which a study from (Mathieson, 1991) reveals that the acceptance are often from economic motivations. This also showed that it has significant influence on an SST adoption (Lule, Omwansa, & Waema, 2012). Specifically on APL aspect, Yuen et al. (2019) showed that transaction cost has significant impact on intention to use in which, transaction cost associated to the cost of searching, learning and cost incurred from the effort related to the use of APL.

2.4 Tools and Methodology Review in APL and related areas

2.4.1 Review methodology related to impact of alternative delivery solutions

The methodology used in the above-mentioned study are summarized in table 3. There are a mix of qualitative and quantitative studies on the different purposes. The first stream of work are quantitative approach, where carbon audit model is used to assess carbon dioxide (CO_2) emissions for a failed delivery in different first time delivery failure rates (10%,30% and 50%), in which the calculation is done on typical van home delivery basis (Edwards, McKinnon, & Cullinane, 2009). Activity based estimation model is used to compare economic and environmental assessment by using cost per parcel and CO_2 per parcel as indicators (Giuffrida, Mangiaracina, & Tumino, 2012). Song, Cherrett, McLeod, & Guan (2009) used quantitative analysis to quantify the impact of first time delivery failure and assess transport and environmental benefits of using CDP networks in different locations instead of leaving all failed deliveries at depot. Orenstein et al. (2019) proposed a

VRP model for the problem of flexible parcel delivery to APL in order to minimize the travel costs of all vehicles, the fixed costs associated with each vehicle that is utilized, and the total penalty associated with all undeliverable parcels Carotenuto et al. (2018) provides a comparison of home delivery and locker base delivery by using Multi depot Capacitated VRP. The analysis discusses the advantages and disadvantages of both delivery methods and identifies the optimal locations for lockers to save cost and time. Gonzalez-Feliu, Ambrosini, & Routhier (2012) provided sequential algorithm to estimate the flows of goods which is substituted by different channel which are shopping trip, home delivery and pickup points. The scenarios are proposed to investigate travelled distance and road occupancy rate. Durand & Gonzalez-Féliu (2015) use empirical simulation approach to compare last mile delivery scenario. The comparison is made on travelled distance, road occupancy, and GHG emission. Wang et al. (2014) conduct simulation using VRP to assess cost structure and operation efficiency of home delivery, reception box and CDP. VRP is also used by McLeod et al. (2006) in analysis to estimate impacts of travel from small to medium size failed deliveries parcels. Customers must travel a certain distance to recover unsuccessful deliveries, either from the carrier's hub or from local CDPs, and the carrier must go a certain distance to deliver products. It also calculated the possible customer benefits of adopting either attended or unattended delivery options to address failed residential deliveries.

Another stream from alternative delivery solution is qualitative approach. There are various methods the studies are conducted. Slabinac (2015) reviewed literatures on last mile delivery efficiency and defined cost drivers of the solutions as well as identify innovative last mile solution to increase efficiency in which APL and pickup points are pinpointed. Similarly, Durand & Gonzalez-Féliu (2015) conduct a literature review to examine the impact of online retailing and the impact of transportation. The review explores carbon impacts of transport and delivery activities related to online retailing. Hofer et al. (2019) uses panel survey and the application on two person groups to estimate emission and travelled distance of customers when using APL in Austria. Iwan et al. (2016) use survey to assess usability and efficiency of parcel lockers based on Polish InPost Company system example.

The study's objective was to assess parcel locker services. The analysis sought to determine the relationship between a sustainable development strategy and the location of parcel lockers in specific cities, assuming that the locations matched the strategy. L. Zhou, Baldacci, Vigo, and Wang (2018) used content analysis to examine the key drivers of the growth of pickup points and lockers in relation to service providers' and retailers' strategies, as well as consumer preferences.

Table 4: Methodology Used to Predict Intention to Use APL

Topic	Authors	Area of study	Method
Understanding consumer motivation and behavior related to self-scanning in retailing	Dabholkar et al. (2003)	Self-scanning	Content Analysis, Confirmatory Factor Analysis, ANOVA,
The role of technology readiness in customers' perception and adoption of self-service technologies	Lin & Hsieh (2006)	Financial service, bank, interactive phone, cenima, kiosks train, airlines	Structural Equation Model
Predicting consumer intention to use mobile service	Y. S. Wang et al. (2006)	M service	Structural Equation Model
An empirical investigation of consumer control factors on intention to use selected self-service technologies	Oyedele & Simpson (2007)	Hotel Library Shopping	Logistic Regression
Investigating passengers' intentions to use	Lu et al. (2009)	Airline self check in service	Structural Equation

technology-based self check-in services			Model
The influence of consumer traits and demographics on intention to use retail self-service checkouts	Lee et al. (2010)	Retail self checkouts	Structural Equation Model
The role of technology readiness in self-service technology acceptance	Lin & Chang (2011)	SST	SEM, Hierachical moderated regression analysis
Assessing the Self-service Technology Encounters: Development and Validation of SSTQUAL Scale	Lin & Hsieh (2011)	Self service technology in general	Structural Equation Model
A comparison of users and non-users of banking self-service technology in Portugal	Proença & Antonia Rodrigues (2011)	ATMs, telephone banking, and internet banking	Bivariate correlation analysis
The impact of forced use on customer adoption of self-service technologies	S. Liu (2012)	Interactive kiosks	Confirmatory factor analysis, MANCOVA
The impact of basic human needs on the use of retailing self-service technologies: A study of self-determination theory	Leung & Matanda (2013)	Supermarket self-checkout	Structural Equation Model
Topic	**Authors**	**Area of study**	**Method**

The impact of e-commerce on final deliveries: alternative parcel delivery services in France and Germany	Morganti, Seidel, et al. (2014)	Automated Parcel lockers	Content Analysis
Final deliveries for online shopping: the deployment of pickup point network in urban and suburban areas	Morganti, Dablanc, et al. (2014)	Pickup point	Literature Review, Face-toFace interview
Travel behaviour in the context of parcel pickups	A. Collins (2015)	CDP	Error components logit model
Behavioral influences on the environmental impact of collection/delivery points	A. T. Collins (2015)	CDP	Error components logit model
Innovations in e-grocery and logistics solutions for cities	Saskia et al. (2016)	drive-in/ drive-out/ in-store	Content Analysis
Acceptability of collection and delivery points from consumers' perspective: a qualitative case study of Christchurch city	Kedia, Kusumastuti, & Nicholson (2017)	CDP	Focus group interview
Grocery pickup creation of value: customers' benefits vs. spatial dimension	Vyt, Jara, & Cliquet (2017)	Pickup point (both drive in and drive out)	In-depth interview
Topic	**Authors**	**Area of study**	**Method**
Measuring customers benefits of click and collect	Jara et al. (2018)	Click and Collect	Structural Equation

			Model
Parcel locker systems in a car dominant city: Location, characterization and potential impacts on city planning and consumer travel access	Lachapelle et al. (2018)	Automated Parcel lockers	Confirmatory factor analysis, Hierarchical cluster analysis
What's in the parcel locker? Exploring customer value in e-commerce last mile delivery	Vakulenko et al. (2018)	Automated Parcel lockers	Focus group interview
An investigation of customers' intention to use self-collection services for last-mile delivery	Yuen, Wang, Ng, & Wong (2018)	Automated Parcel lockers	Confirmatory factor analysis, Hierarchical regression analysis
An innovation diffusion perspective of e-consumers' initial adoption of self-collection service via automated parcel station	X. Wang et al. (2018)	Automated Parcel lockers	Structural Equation Model
Decomposing service conveniences in self-collection: An integrated application of the SERVCON and Kano models	X. Wang, Wong, Teo, Yuen, & Li (2019)	Automated Parcel lockers	Quantitative analysis
Topic	**Authors**	**Area of study**	**Method**
The determinants of customers' intention to use smart lockers for last-mile	Yuen et al. (2019)	Automated Parcel lockers	Focus group interview

deliveries

Understanding consumers' behavior to adopt self-service for last mile delivery	Zhou et al. (2020)	Automated Parcel lockers	Structural Equation Model

2.4.2 Tools and Methodology used in factors influencing Intention to Use

Various methodologies are used to examine factors influence customers' intention to use last mile delivery service options both in context of SST, CDPs and APL. From quantitative approach, Structural equation modeling is mostly used to investigate the interactions between multiple latent components (Jara et al., 2018; H.-J. Lee et al., 2010; Leung & Matanda, 2013; Lin & Chang, 2011; Lin & Hsieh, 2006; Lu et al., 2009; Xueqin Wang et al., 2018; Yuen et al., 2019; M. Zhou et al., 2020). It is considered a plausible explanation for the relationship between measures when two matrices are consistent with one another (Doncaster & Davey, 2007). A combination of methods is widely used in adoption contexts. S. Liu (2012) utilized a variety of methods to ascertain how technology anxiety and trust affect customers' satisfaction and behavioral intentions when it comes to SSTs. The study employed Principle Component Analysis (PCA), followed by confirmatory Factor Analysis (CFA). Additionally, it used Multivariate Analysis of Covariance (MANCOVA) to examine whether subjects with varying demographic characteristics differed in their responses to study variables such as technology trust, technology anxiety, forced use, customer satisfaction, and behavioral intentions. CFA and Analysis of Variance (ANOVA) analysis are used to investigate consumer reason for both using and avoiding the use of SST (Dabholkar, Bobbitt, & Lee, 2003). These combinations are believed to offer richer findings. Proença and Antonia Rodrigues (2011) adopted bivariate correlation analysis using the Pearson coefficient was used to examine the relationship between consumer behavior and SST use. CFA is also to examine the impact of technology readiness on SST customers' acceptance by Leung and Matanda (2013), whereas Yuen et al. (2018) shows the impact of innovation characteristics from self-collection services on customers' intention to use. Hierachical regression analysis is used in SST

and specifically to APL context Yuen et al. (2018) to show the significance of relationships between variables in the study on customers' intention to use SST. While X. Wang, Wong, et al. (2019) used quantitative analysis to examine self-collection service attributes in relation to consumers' satisfaction formation. Lachapelle et al. (2018) used Hierarchical clustering analysis to group type of APL locations where customers tend to use most frequently.

From a qualitative perspective, focus group is chosen to explore APL location characteristics where customers tend to use (Lachapelle et al., 2018) and investigate to provide insight into customers' perceptions of parcel lockers and customer value regarding APL as SST (Vakulenko et al., 2018). Similarly, Kedia et al. (2017) used focus group as a technique to investigate acceptance of CDPs by residents in Christchurch, which is employed to explore a specific set of issues.

In depth interview is also used by Vyt, Jara, & Cliquet (2017) to explore customers' value in self-collection service by retailers as it is stated that there is an absence of theory specially dedicated to this phenomenon and reveal the critical aspects. Morganti, Dablanc, & Fortin (2014) uses both interviews and questionnaires to identify main variables and constraints of adopting pickup points. the study provides and analysis of the spatial distribution of pickup point in France. The framework for pickup points network consist of retail system, transport system, demographic indicators, parcel flow within the network, centers and nodes for city users. Morganti, Seidel, Blanquart, Dablanc, & Lenz (2014) uses content analysis to compare the alternatives to home delivery in France and Germany, which also include an analysis of key drivers of the development of parcel lockers and pickup points. Similarly, Saskia, Mareï, & Blanquart (2016) also used content analysis to compare grocery pickup in France and Germany. The alternatives is similar to pick up points in case the storage and customers spend efforts on driving out to pick up the groceries.

2.4.3 Potential demand prediction and methodology review

Numerous studies on delivery alternatives were conducted aimed to predict the probability of potential customers and demand. Table 5 summarizes all tools used to identify significant factors impact APL adoption and to predict potential

demand. Since APL literatures is limited, the related literatures from delivery alternative and related fields are gathered as for references. The solutions are used in a number of different ways, with different methodologies being used to assess and forecast behavior changes. Those methods widely used are Linear regression, Logistic regression, binary logit model, multinomial logit model (De Luca & Di Pace, 2014; Joerss, Schröder, Neuhaus, Klink, & Mann, September 2016; J. W. Weltevreden & Rotem-Mindali, 2009). Different studies also have different prediction objectives. In forecasting, comparative quantitative analysis is used to generate broad scenarios (Hofer, Flucher, Fellendorf, Schadler, & Hafner, 2019; J. W. Weltevreden & Rotem-Mindali, 2009). Utilizing a panel survey and two person groups, the corresponding study examined the change in customer mobility behavior as a result of using APL. Van Duin, Wiegmans, van Arem, & van Amstel (2019) employed cost-effective analysis, multi-criteria analysis, and simulations in van Amstel and choose the optimal number of APL. Multiple linear regression is employed in another study to assess the probability of redelivery and delivery outcome using a variety of methods, including service points. (J. Van Duin, De Goffau, Wiegmans, Tavasszy, & Saes, 2016) and presented the potential reduction in redelivery for each alternative.

J. Van Duin et al. (2016) conducted a study and showed that the distance has most significant influence on the efficiency and that related to population density. Moreover, the population density has a negative influence on the delivery efficiency. Stated preference and reveal preference methods were used by Oliveira, Morganti, Dablanc, & Oliveira (2017) to examine the demand for automated delivery stations. The ease of access to the location and the security of the area appealed to the potential demand.

Socio-demography and operational factors were taken in a study from Meng, Koh, & Wong (2016). Those operational factors are travel distance and streetscape, which showed that they impact traveler mode choice decision. The results also revealed significant relationships between age, gender, travel distance, household income and other attributes relevant directly to last mile mode choice. C. Liu, Wang, and Susilo (2019) provided analysis of external effects such as CO_2 of CDP by incorporating mode choice and trip chaining decisions. The analysis employs cross-

nested logit model. The results showed that using car is preferred by young adults living with parents/spouses, single adults and partnered adults. Additionally, the model predicts the probability of selecting different modes of travel for distinct trip chaining purposes. Vehicle Kilometers travelled (VKT), hightest vkt is identify as it implied that accessibility to CDP is not good. Therefore, the study suggested the relocation of the current CDP to reduce VKT. Binomial logistic regression is used in a study from J. W. Weltevreden & Rotem-Mindali (2009). This technique is used to identify characteristics of CDP users.

Table 5: Literature and Tools Used to Predict Demand and Probability to Use

Topic	Authors	Tools
Improving home delivery efficiency by using principles of address	J. Van Duin, De Goffau, Wiegmans, Tavasszy, & Saes (2016)	Multiple Linear Regression
Analysis of the potential demand of automated delivery station for e-commerce delivery in Brazil.	Oliveira, Morganti, Dablanc, & Oliveira (2017)	Multinomial logit model
Assessing the impacts of collection-delivery points to individual's activity-travel pattern: a greener last mile alternative?	C. Liu, Wang, & Susilo (2017)	Panel cross-nested logit model
B2c e-commerce logistics: the rise of collection-and-delivery points in The Netherlands	J. W. J. Weltevreden (2008)	Binomail logit model Linear regression
Mobility effects of b2c and c2c e-commerce in the Netherlands: a quantitative assessment	J. W. Weltevreden & Rotem-Mindali (2009)	Comparative quantitative analysis
Modelling the propensity in adhering to a carsharing system: a behavioral approach	De Luca & Di Pace (2014)	Binomial logit model

Estimation of changes in Customer's Mobility Behavior by the use of Parcel Locker	Hofer, Flucher, Fellendorf, Schadler, & Hafner (2019)	Comparative quantitative analysis
Carsharing systems demand estimation and defined operations: a literature review	Jorge & Correia, (2013)	Multi-techniques
Investigating household vehicle ownership, mode choice and trip sharing decisions using combined revealed preference/stated preference Nested Logit Model	Dissanayake & Morikawa (2010)	Nested Logit Model
Influence of Socio-Demography and Operating Streetscape on Last-Mile Mode Choice	Meng, Koh, & Wong (2016)	Multimodel logit regression
From home delivery to parcel lockers: A case study in Amsterdam	R. van Duin, Wiegmans, van Arem, & van Amstel (2019)	Mathematic modelling
Modeling the propensity to join carsharing using hybrid choice models and mixed survey data	Efthymiou & Antoniou (2016)	Ordered logit model

De Luca & Di Pace (2014) used Binomial logit model to simulate the demand segment for carsharing service. Potential demand depends on mode choice behavior, transport modes available as well as the supplied level of service, Activity-based characteristics such as weekly travel frequency, distance, and knowledge of service and' socio-economic, which are age, gender, income, however, they show no significant which is different from other studies. Multinomial logit model is commonly used widely to estimate potential demand (Meng et al., 2016; Oliveira et al., 2017). Dissanayake & Morikawa (2010) investigated household travel behavior using nested logit model in respect to vehicle ownership, mode choice, and trip sharing decision. The study purposely aims to forecast travel demand for new transport service. In

order to predict, ordered logit model is used, in the context of carsharing, willingness to join the service is predicted in Greece (Efthymiou & Antoniou, 2016). The variables impact willingness to use service are included demographic characteristics and travel attributes which are social taxi, income, environment conscious, satisfaction on current travel pattern. And the results show that middle income groups are likely to use carsharing. Satisfaction of current travel pattern is negatively influencing the willingness to join.

Chapter 3: Methodology

This chapter consists of three parts explaining methodology of this study. The first part is research process which outlines the steps used. The second part is scope and data used in predators of probability to use APL. Stated preference survey, a technique used to collect data for this study. The third part is the review of the methodology to identify which factors significantly influencing intention to use APL. And the last part is the analysis methodology for environmental impact assessment from APL adoption.

3.1 Research Process

The study starts with literature review on three aspects. The first aspect is impact of APL adoption both economic and environment perspectives, technique used to predict potential demand and factors influencing APL adoption. Second part is to collect data from stated preference survey to run multiple linear regression to provide prediction model of APL use. Last is to provide a predictor of intentions to use APL. The process is described in figure 5.

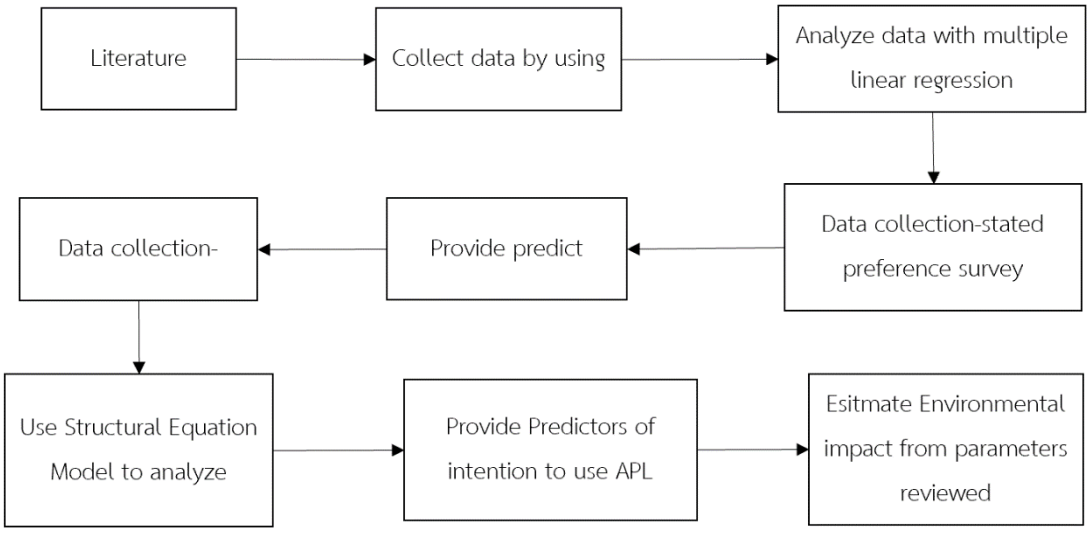

Figure 5: Research Process

3.2 Predictors of probability to use APL- Scope and Data Used

To evaluate potential demand for APL in the scope of the study, stated preference (SP) was chosen. SP is a well-known technique to nonmarket valuation that relies on respondents responding to carefully worded survey questions (Brown, 2003). SP's response can result in the creation of a scaled, rated, choice, amount, or other sign of preference. The surveys are considered useful in forecasting as they can produce consistent preferences based on expressed preferences from hypothetical alternatives (Fujii & Gärling, 2003). The majority of research that use SP are aimed at determining and identifying preferences for transportation policy, as well as their consequences and predicting stakeholders' preferences (Holguín-Veras, Silas, Polimeni, & Cruz, 2008; Marcucci, Gatta, Marciani, & Cossu, 2017; Marcucci, Gatta, & Scaccia, 2015; L. K. Oliveira, Braga, & Abreu, 2010; L. K. d. Oliveira, Morganti, Dablanc, & Oliveira, 2017). For instance, those studies include Efthymiou and Antoniou (2016) analysis of prospective demand for carsharing, and L. K. d. Oliveira et al. (2017)'s analysis to predict potential demand for APL in Brazil.

After literature has been reviewed, variables are selected to be in questionnaires as shown in table 7 and 8. The variables are divided into 3 groups: behaviors, preference and socio-demographic,. The dependent variable is the likelihood of using APL, which is measured on a scale of 0 to 100. This order scale makes it easier for respondents to respond, with 0 indicating that they are unlikely to use at all and 100 indicating that they are most likely to use. Questionnaires are presented in Appendix. Socio-demographic are included in the last part of questionnaires, including gender, age, marital status, income, occupation, and education.

Table 6: Literatures with SP

Topic	Authors	Objectives
Analysis of the potential demand of automated delivery station for e-commerce deliveries in Belo Horizonte, Brazil	Oliveira, Morganti et al. (2017)	To evaluate prospective users in light of two different delivery services (HD vs APL)
City logistics modelling efforts: Trends and gaps- a review.	Anand, Quak, van Duin, & Tavasszy (2012)	To define criteria of city logistics from stakeholders' point of view
Behavioral implication of non-linear effects on urban freight transport policies: the case of retailers and transport providers in Rome	Gatta & Marcucci (2016)	To specify stakeholders' preference on transport policies
Intra-agent heterogeneity in urban freight distribution: the case of own-account operators	Marcucci & Gatta (2013)	To quantify private operators' willingness to utilize urban distribution centers
Design and development of a stated choice experiment for interdependent agents: accounting for interactions between buyers and sellers of urban freight services	Puckett, Hensher, Rose, & Collins (2007)	To capture independent preferences and effects of interactivity among buyers and sellers on urban freight services
Relevant attributes in overnight goods delivery: Researchers', transporters' and retailers' preference in urban distribution	Oliveira, Braga, & Abreu (2010)	To elucidate the characteristics necessary for overnight goods delivery in urban areas from the perspective of researchers, transporters, and retailers

Topic	Authors	Objectives
An investigation on the effectiveness of joint receiver–carrier policies to increase truck traffic in the off-peak hours.	Holguín-Veras, Silas, Polimeni, & Cruz (2008)	To investigate receiver's scenarios that encourage off-peak deliveries and estimate market share
On finite sample performance of confidence intervals methods for willingness to pay measures	Gatta, Marcucci, & Scaccia (2015)	To compare the performance of methods for constructing confidence intervals for measures of willingness to pay in a choice-modeling context using a finite sample
Urban freight, parking and pricing policies: An evaluation from a transport providers' perspective	Marcucci, Gatta, & Scaccia (2015)	To determine the preference of transportation providers for an alternative to traditional loading bays and to determine pricing policy
How good are retailers in predicting transport providers' preferences for urban freight policies?... and vice versa	Marcucci & Gatta (2016)	To examine retailers' and transportation providers' ability to predict one another's responses to agents' performance under alternative urban freight policies
A new approach to predict the market and impacts of round-trip and point-to-point carsharing systems: case study of London	Le Vine, Lee-Gosselin, Sivakumar, & Polak (2014)	To predict prospective subscribers of carsharing service

Table 7: Variables from literature review

Categories	Variables	Sources
Demographic	Age	Collins (2015); Goethals, Leclercq-Vandelannoitte, & Tütüncü (2012); Lachapelle, Burke, Brotherton, & Leung (2018); Liu, Wang, & Susilo (2017); Meng, Koh, & Wong (2016); Oliveira, Morganti, Dablanc, & Oliveira (2017); Xiao, Wang, & Liu, (2018); Yap et al. (2016); Yuen, Wang, Ma, & Wong, (2019); Yuen, Wang, Ng, & Wong (2018)
	Gender	Chen, Yu, Yang, & Wei, (2018) ; Collins (2015); Goethals et al. (2012); Kedia, Kusumastuti, & Nicholson, (2017); Lachapelle et al., (2018) ; Liu et al. (2017); Meng et al. (2016); Oliveira et al., (2017); Weijters, Rangarajan, Falk, & Schillewaert, (2007); Xiao et al., (2018); Yap et al., 2016; Yuen et al., 2018)
	Individual income	Chen et al., (2018); Collins, 2015; Lachapelle et al., (2018); Oliveira et al., 2017; Weijters et al., (2007); Xiao et al., (2018); Yap et al., (2016)
	Education Level	Chen et al. (2018) ; Oliveira et al. (2017); Xiao et al. (2018); Yap et al. (2016); Yuen et al. (2019); Yuen et al. (2018)
	Marital status	Xiao et al. (2018)
	Occupation	Chen et al. (2018); Lachapelle et al. (2018); Meng et al. (2016); Yuen et al. (2019)
Behavioral	Household living type	Collins (2015); Lachapelle et al. (2018); Xiao et al. (2018); Yuen et al. (2019); Yuen et al. (2018)

Categories	Variables	Sources
	House ownership	Xiao et al. (2018)
	Frequency of shopping	Buldeo Rai, Verlinde, & Macharis (2019); Oliveira et al., (2017); Xiao et al., (2018); Yuen et al. (2019)
	Product purchased	Oliveira et al. (2017); Yuen et al (2019); Yuen et al. (2018)
	Internet access	Lachapelle et al. (2018)
	Commute	Lachapelle et al., (2018); Liu et al. (2017); Yap et al. (2016)
	Number of hours surfing internet	Davies, Dolega, & Arribas-Bel (2019)
	Experience shopping online	Weltevreden (2008)
	Area of living (population density)	Lachapelle et al. (2018) ; Liu et al., (2017); Morganti, Dablanc, & Fortin (2014)
Preference	Distance	Kedia et al. (2017); Liu et al. (2017); McLeod, Cherrett, & Song (2006); Morganti et al. (2014); Wang, Wong, Teo, Yuen, & Li (2019)
	Traveling time	Oliveira et al. (2017); Weltevreden (2008)
	Service time	Lachapelle et al. (2018); Liu et al. (2017); Oliveira et al. (2017); Wang et al. (2019)
	Location Facilities	Chen et al. (2018); Lachapelle et al. (2018); Morganti et al. (2014); Oliveira et al. (2017); Weltevreden (2008)

Categories	Variables	Sources
	Price set	Kedia et al. (2017); Lachapelle et al. (2018); Oliveira et al. (2017)
	Purpose of travelling	Hofer, Flucher, Fellendorf, Schadler, & Hafner, (2019); Liu et al. (2017); Meng et al. (2016)
	Preferred location type	Lachapelle et al. (2018); Morganti et al. (2014); Oliveira et al. (2017); Weltevreden (2008)

Table 8: Variables used in this study

Dependent variable		
	Probability to use	0-100
Independent Variable		
Demographic	Age	- under 18 - 18-25 - 26-35 - 36-45 - > 45
Independent Variable		
Demographic	Gender	Male Female
	Occupation	-student - Full time employee - freelance - business owner - civil servant - unemployed
	Marital Status	- single - married - others

Independent Variable		
	Education level	- Lower than bachelor degree - Bachelor's degree - Master degree - PhD
	Individual Income (THB)	- >15,000 - 15,001-30,000 - 30,001-45,000 - 45,001-60,000 - >60,000
Behavior	Area of living	district
	Household living style	- living alone - living with parents - living with spouse - living with spouse and children - others
	Type of accommodation	- House - condominium/ apartment - others
	Frequency of online shopping	- once a month - 2-3 times/month - >= 4 times/ month
	Frequently product purchased online	- Clothes/accessories/cosmetics - Grocery - Electronic goods/mobile phones/ IT accessories - others
	Home Internet access	Yes/ No

Independent Variable		
	Travel mode	- private car - public transport - others
	Number of hours surfing internet per day	- < 2hours - 2-5 hours - >5 hrs
Preference	Travelling distance	
	Preferred branch	
	Reason choosing stated location	Near home, Near office Along the way, others
	preferred service time	10.00-18.00 hr 18.00-22.00 hr 22.00-06.00 hr 06.00-10.00 hr
	Preferred APL location	
	Price set	-referred price, discounted price

Sample size

The purpose of a pilot trial is not to demonstrate a treatment's superiority, but to evaluate the processes in order to obtain estimated parameters for the main sample size. Thus, the formula to calculate sample size in normal treatment is not applicable. In this study, a pilot sample size of 30 is chosen. There are several methods for estimating the sample size for a pilot trial; the most straightforward is to use sample size rules of thumb (Browne, 1995), with the rule to have at least 30 subjects or greater to estimate a parameters.

For Main distribution, there are several approaches to determine the sample size. Bartlett, Kotrlik and Higgins (2001) argued for the different sample size for dichotomous (categorical) variables and continuous variables. Though sample based on proportion is conservative, it has a cost implication for data collection and processing (Bartlett, Kotrlik, & Higgins, 2001). Yamane (1967) proposed a formula to calculate sample size according to this equation (Lamola & Yamane, 1967).

$$n = \frac{N}{1+Ne^2} \quad (3.1)$$

n = minimum returned sample size

N= the population size

e = level of precision or sampling of Error

However, Richards and Ben-Akiva (1975) mentioned that the sample size of 200- 500 are sufficient for this SP, and it is rational. Moreover, most of SP survey sample size can be between 75-100 sample since one sample can result in different scenarios (de Dios Ortúzar & Willumsen, 2011).

To explore the effectiveness of the survey, a pilot research was conducted online in April 2020. After analyzing the questions, an APL explanation and APL images were added to provide a better explanation. Moreover, some questions are adjusted to be shorter and more precise. The main survey was conducted with questionnaires distributed to 150 respondents, which aimed to have in total 900 observations. Both online and face-to-face distributions were used. The data for the offline survey was collected at a post office and a university. The reason for having an offline channel is because solely using the internet may result in optimistic results since respondents tend to respond favorably (Dillman, Smyth, & Christian, 2011). The survey took place between June and July 2020. Each respondent was permitted to submit only one response. Data cleaning was performed by removing those that failed the quality checks. Thus, 718 observations were taken for further analysis from the total number of observations collected. The survey data was analyzed using descriptive and inference statistics. In terms of inference statistics, a stepwise method was used to calculate the impacts of multiple socioeconomic variables and

preferences on the probability of adopting APL using a multiple linear regression model. Since the dependent variable is probability scale, in order to interpret the result better and easier, probability is converted into odds and log odds respectively to get symmetric value from – α to α. It begins with probability given by each respondent, which is p. Then the probability of failure is q or 1-p. Odds of interested event are defined as $\frac{p}{1-p}$. That is, the odds of not-interested event would be $\frac{1-p}{p}$, in which odds of interested case and not-interested case are reciprocals of one another. Conversion to log odds results in symmetry around zero as earlier mentioned, which is easier for analysis (Jaccard, 2001). Thus, obtaining the natural logarithm for a given probability of the odds which can be written as;

$$ln\frac{p}{1-p} \tag{3.3}$$

Where p = the probability of using APL

1-p = the probability of not using APL

When interpreting the result, since Log (odds) = $e^{\ln(odds)}$, turning log odds into odds ratio and into probability by using odds divided by sum of 1 and odds, which can be expressed as;

$$\frac{odds}{1+odds} \tag{3.3}$$

or, the probability can also be reconstructed as;

$$\frac{\exp(Ln(odds))}{(1+\exp(Ln(odds)))} \tag{3.4}$$

Since the outcome of the linear regression is a probability between 0 and 1, which do not influence the probability linearly any longer. Therefore, equation is reformulated for the interpretation.

The regression is constructed as

$$Ln(\frac{p}{1-p}) = \beta 0 + \beta 1 x1 + \beta 2 x2 + \ldots + \beta\, nxn \quad (3.5)$$

Where $\frac{p}{1-p}$ is odds where, p is Probability of using APL

β I is coefficient of independent variable xi

xi is independent variables

The result will be interpreted by converting (3.4) to;

$$\frac{p}{1-p} = e^{\beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_n x_n} \quad (3.6)$$

However, to interpret result in log odds is difficult on their own, and doesn't provide much meaning. Log odds could be converted to normal odds using exponential function. The result of all the mathematical manipulations is that the odds ratio can be computed by calculating odds, which is illustrated as;

$$\frac{p}{1-p} = e\,\beta \quad (3.7)$$

The formula to convert probability to odds and log odds are summarized in table 9.

Table 9: the conversion of probability to odds and to log odds

	Formula	sample
Probability	p	0.7
Odds	$\frac{p}{1-p}$	2.33
Log Odds	$ln\frac{p}{1-p}$	0.85

In this paper, marginal effects is used to summarize an independent variable's effect from model prediction. There are numerous advantages by using

marginal effects (Mize, 2019). First, it helps to measure an independent variable's effect when there is multiple linked coefficient in the model. Second, it helps to avoid problematic identification issues. And lastly, it helps to express and interpreted different metric than regression coefficients.

Average Marginal Effect (AME) is calculated to explain the effect of independent variable to the change in the probability of the event. The average of the marginal effect across all units in sample is calculated. Thus, it reveals the change in probability if there is a change in independent variable by a very small amount while the remaining variables remain unchanged. The marginal effects calculation is expressed as:

$$\frac{dy}{dx} = \beta * y * (1 - y) \quad (3.8)$$

Results analysis is presented in the next chapter.

3.3. Factors influencing Intention to APL Adoption - Research setting and measurement

This study examines its research model and hypotheses using structural equation modeling, which is considered to be the most appropriate method. The sections that follow describe the measurement items that were employed to operationalize the constructions. Pilot study and sampling technique and sample size, as well as the face validity of the survey are explained in this chapter.

Measures

The questionnaire consisted of a series of items measuring attitude toward APL and intention to use APL. The questionnaire consists of two parts; the first part is designed to test the degree of the respondent's agreement with the items and constructs. Total 46 items were adopted from several research, which are illustrated in table 10.

The constructs of the model consist of 7 constructs: Perceived usefulness, perceived ease of use, perceived control, attitude towards APL, trialability, technology anxiety, and transaction cost.

Perceived ease of use (PEU) is defined as an individual's belief that utilizing a particular system would be effortless. (Demoulin Nathalie & Djelassi, 2016). There are six items which are convenience, easy application, convenient location, easy process, easy to learn and easy to access (Blut et al., 2016; C.-F. Chen, 2019; C.-F. Chen & Chao, 2011; Demoulin Nathalie & Djelassi, 2016; Y.-H. Lee et al., 2011; Lin & Chang, 2011; Lule et al., 2012)

Perceived usefulness (PU) refers to an individual's belief that a particular system would assist him or her in performing better at work in an organizational setting (Davis, Bagozzi, & Warshaw, 1989). There are nine items adopted, which are speed of delivery, no waiting time at home, carbon emission, better than home delivery, reduce damaging chance from parcel, lifestyle compatible, save delivery time and reduce delivery failure (Blut et al., 2016; ; Demoulin Nathalie & Djelassi, 2016; Y.-H. Lee et al., 2011; Lule et al., 2012; Rauniar et al., 2014).

Perceived control (PC) is the belief in one's ability to command and exert control over the process and outcome of a self-service encounter (Joel, Daniel, Babakus, & Blakeney Horky, 2014). It was accessed for six items: be able to select convenient APL location, be able to select convenient time, be able to travel, have enough knowledge, be able to select both location and time, be able to control when to go to get parcel (Y. Chen, Yu, Yang, & Wei, 2018; Joel et al., 2014; Oyedele & Simpson, 2007).

Attitude towards APL (ATT) was assessed by four items which are speed, convenience, satisfaction, and good (C.-F. Chen & Chao, 2011; Demoulin Nathalie & Djelassi, 2016; Y.-H. Lee et al., 2011; Lin & Hsieh, 2006; Lule et al., 2012; Nordfjærn et al., 2014; Şimşekoğlu, Nordfjærn, & Rundmo, 2015).

Trialability (TRIAL) refers to the ease with which an innovation can be tried out or tested on a small scale. It is expected that customers who perceive APL services as easily tried and tested will have fewer reservations about using them. There were five items adopted from (Blut et al., 2016; Strömberg et al., 2016; Weigel, Hazen, Cegielski, & Hall, 2014) which are location to try, change to try, easiness to experiment functions, easily access and experience, and trying out when necessary.

Technology anxiety (TA) is important in determining consumer decisions to engage with, adopt, or experiment with new technology (Venkatesh et al., 2003). For SST options, it is crucial to address the technology anxiety of potential users (Matthew L. Meuter, Ostrom, Bitner, & Roundtree, 2003). There are four items to be assessed which are fear of making mistake, inconfidence for capability, avoid as it requires a certain degree of capability, feeling apprehensive (Blut et al., 2016; C.-F. Chen et al., 2020; Matthew L Meuter, Ostrom, Roundtree, & Bitner, 2000).

Transaction cost are defined as opportunity cost incurred from using APL. This associated with using APL in five items: sourcing information, learning, traveling, paying extra cost, wasting time. The lower the transaction cost, the higher the intention toward an adoption. These items were adopted from (Lule et al., 2012; Weber & Mayer, 2014; Yuen et al., 2019; Yuen et al., 2018).

The hypotheses are showed below:

H1: Trialability has positive impact on perceived ease of use

H2: Trialability has positive impact on perceived usefulness

H3: Perceived ease of use has positive effect on Perceived usefulness

H4: Perceived ease of use has positive effect on Attitude towards APL

H5: Perceived usefulness has positive effect on Attitude towards APL

H6: Attitude towards APL has positive effect on Intention to use APL

H7: Perceived control has positive effect on Intention to use APL

H8: Technology anxiety has negative effect on Intention to use APL

H9: Transaction cost has negative effect on Intention to use APL

In addition to the above-mentioned measures, a socio-demographic including gender, age, marital status, education, occupation, income was included in the questionnaire. Respondents were asked to rate their intentions and to which degree they agree with the given statement.

The framework was reviewed and validated by the experts in the industry show in table 10, The name of the experts are presented in table 11. Proposed research model for Intention to use APL is shown in figure 6.

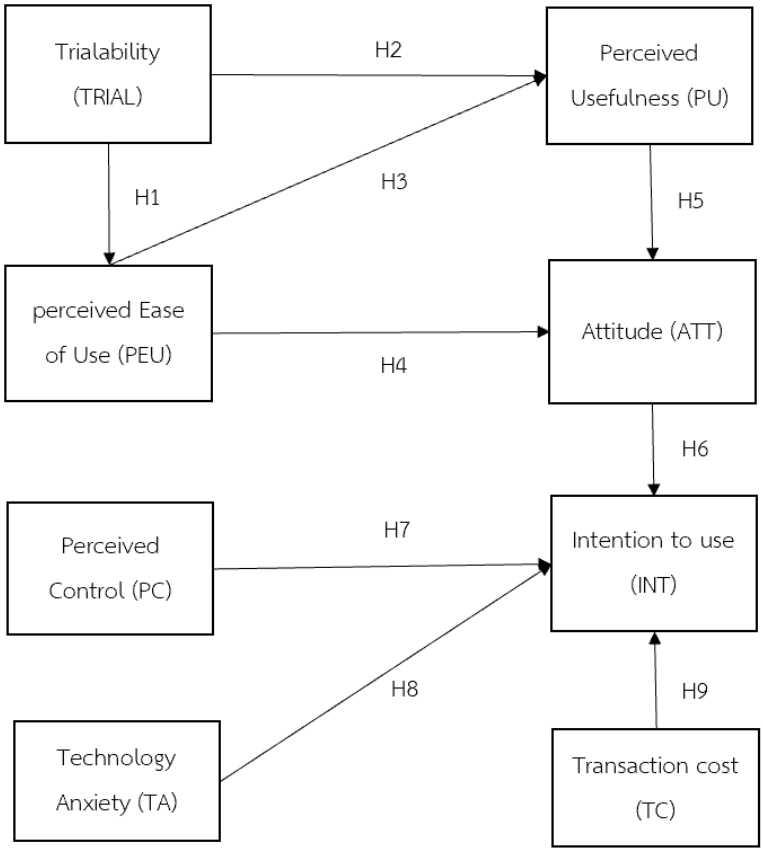

Figure 6: Proposed Research Model for Intention to Use APL

Face Validity and Survey Development

Before distributing questionnaire, validity had been tested with Face validity, which is to examine by asking experts to judge whether the developed survey measure the desired content.

Table 10: Constructs and Items Adoption

Constructs	Items	Adopted sources
Perceived ease of use (PEU)	PEU1 - I think to get my parcel at the time I'm convenient make it easier PEU2 – I think it is easy to use the application to get my parcel	(Blut et al., 2016; C.-F.

Constructs	Items	Adopted sources
	PEU3 – I think convenient location make it easy to get my parcel PEU4 – I think I can understand easily to get parcel from APL PEU5 – I think I can easily learn how to use APL PEU6 – I think it' s easy to access APL location	Chen, 2019; C.-F. Chen & Chao, 2011; Demoulin Nathalie & Djelassi, 2016; Y.-H. Lee et al., 2011; Lin & Chang, 2011; Lule et al., 2012; Rauniar et al., 2014)
Perceived usefulness (PU)	PU1 - I think APL is the way to get my parcel delivered faster PU2 - I think that using APL, I don't need to wait for delivery at home or ask someone else to do it PU3 - I think delivery to APL reduce carbon emission PU4 - I think delivery to APL is better than delivery to home PU5 - I think that delivery to APL reduce chance parcel get damaged PU6 - I think that delivery to APL fit with my lifestyle PU7 – I think that delivery to APL save delivery Leadtime PU8- I think that delivery to APL allow me to get my parcel in "out of working hours" PU9- I think delivery to APL reduce home delivery failure	(Blut et al., 2016; Collier & Barnes, 2015; Demoulin Nathalie & Djelassi, 2016; Y.-H. Lee et al., 2011; Lule et al., 2012; Rauniar et al., 2014)

Constructs	Items	Adopted sources
Perceived control (PC)	PC1 – I think that delivery to APL allow me to select APL location that I'm convenient PC2 – I think that delivery to APL allow me to select time schedule that I'm convenient PC3 – I think that I can travel to get my delivered parcel PC4 – I think I have enough knowledge and understanding to use APL PC5 – I think that I can select both location and time that I'm able to go and get my delivered parcel PC6 – I think that I can control when to go and get my delivered parcel	Y. Chen et al. (2018); Joel et al. (2014); Oyedele & Simpson (2007)
Attitude toward APL (ATT)	ATT1- overall, I think receiving parcel from APL is faster than delivery to home ATT2- overall, I think receiving parcel from APL increase convenience to get delivered parcel ATT3- overall, I think receiving parcel from APL satisfy me ATT4- overall, I think receiving parcel from APL is a good idea	C.-F. Chen & Chao, (2011); Demoulin Nathalie & Djelassi (2016); Y.-H. Lee et al. (2011); Lule et al.(2012); Nordfjærn et al., (2014); Şimşekoğlu et al.(2015)
Trial ability (TRIAL)	TRIAL1 – I think that I would use APL if I know where I can try TRIAL2 – I think that I would use APL if I have chance to try TRIAL3 – I think I would use if I know it is easy to experiment functions	Blut et al. (2016); Strömberg et al. (2016); Weigel et al. (2014)

Constructs	Items	Adopted sources
	TRIAL4 – I think that I would use APL if I can access and experience its TRIAL5 – I think I would use APL if I can try it when necessary	
Technology anxiety (TA)	TA1 – I hesitate to use new automated system for fear of making mistake I cannot correct TA2 – I feel not confident in my ability to use new automated system TA3 – I avoid automated system because it requires a certain degree of capability TA4 – I feel apprehensive about using APL	Blut et al., (2016); C.-F. Chen et al. (2020); H.-J. Lee et al. (2010); Matthew L Meuter et al. (2005); Matthew L Meuter et al. (2000)
Transaction cost (TC)	TC1- I feel that I have to make significant efforts to source information on location and how to use TC2- I feel that I have to make a significant effort to learn how to use APL TC3- I feel that I have to make a significant effort to travel to get parcels at APL TC4- I feel that I have to pay extra cost to get parcel at APL TC5- I feel that I have to waste time traveling to get parcel at APL	Lule et al. (2012); Weber & Mayer (2014); Yuen et al. (2019); Yuen et al. (2018)
Intention to use (INT)	INT1- I feel comfortable to use this APL INT2- I would recommend APL to my friends INT3- I would say positive things about APL to my friends	Y. Chen et al. (2018); Kang, Jayaraman, Soh, & Wong (2019)

Constructs	Items	Adopted sources
	INT4- I intend to use this APL to receive my parcels INT5- I consider the use of APL to be the first choice for receiving parcel INT6- I would choose to try this APL service in the future INT7- I think it is possible for me to use APL next time	Lai & Chen, (2011); Lin & Hsieh (2006); Nordfjærn et al. (2014); Şimşekoğlu et al. (2015); Yuen et al. (2019); Yuen et al. (2018)

Table 11: Name of the Expert

	Name	Position
1	Mr. Porjeth Jidpipatpong	General Manager, Box24 Co., LTD
2	Mr. Thanom Khingtong	Head of Branch Thailandpost (Ladkrabang)
3	Mr. Thananan Chatiyananda	Logistics Director, Sivadon Distribution Co., LTD

The questionnaires were presented to experts from relevant field for suggestion for improvement by using item-objective congruence (IOC). In this process, the questionnaire was check by three experts. The IOC was used to evaluate the items of the questionnaires base on the score range from -1 to 1, which 1 means congruent, 0 means questionable and -1 means incongruent. Any item with lower than 0.5 would be revised, while those above 0.5 were maintained.

Table 12: IOC result

Construct	Variable	IOC
Perceive Ease of Use	PEU1	0.67
	PEU2	1.00

Construct	Variable	IOC
	PEU3	0.67
	PEU4	0.67
	PEU5	0.67
	PEU6	1.00
Perceive Usefulness	PU1	0.67
	PU2	0.67
	PU3	1.00
	PU4	0.67
	PU5	0.67
	PU6	1.00
	PU7	0.67
	PU8	1.00
	PU9	1.00
Perceive Control	PC1	0.67
	PC2	1.00
	PC3	0.67
	PC4	1.00
	PC5	0.67
	PC6	0.67
Attitude	ATT1	0.67
	ATT2	1.00
	ATT3	1.00
	ATT4	0.67
Transaction cost	TC1	0.67
	TC2	1.00
	TC3	1.00
	TC4	1.00
	TC5	1.00
Trialability	TRIAL1	1.00

Construct	Variable	IOC
	TRIAL2	1.00
	TRIAL3	1.00
	TRIAL4	0.67
	TRIAL5	1.00
Intention to use	INT1	1.00
	INT2	1.00
	INT3	1.00
	INT4	1.00
	INT5	1.00
	INT6	1.00
	INT7	1.00

Pilot Study

The questionnaire was tested with 40 respondents that are not in the sample group. The questionnaire was distributed to convenient sample where the aim and objectives of the study were given to participants and give opportunities for them to enquire about the survey. After the data collection process, reliability refer to constructs' internal consistency and ability to generate the same findings under the same situations. Hair (2009) claimed that reliability values between 0.6-0.7 are acceptable for exploratory research.

Cronbach's alpha is used to identified the reliability value and ensure internal consistency within the items. The value of coefficient Cronbach's Alpha are illustrated as followings (George & Mallery, 2010), where >0.9 means excellent, ≥ 0.8 means good, ≥ 0.7 means acceptatble, ≥ 0.6 means questionable, ≥ 0.5 means poor and unacceptable is <0.5. the reliability and validity in this study are showed in table 13 and 14 which means all items are at good level.

Table 13: Seven constructs and 46 Variables in the research model

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.910	.918	42

Name of Construct	**no. of items in the questionnaire**	**Observed items code as variables**
Trialability	5	TRIAL1, TRIAL2, TRIAL3, TRIAL4, TRIAL5
Perceived Usefulness	9	PU1, PU2, PU3, PU4, PU5, PU6, PU7, PU8, PU9
Perceived Ease of Use	6	PEU1, PEU2, PEU3, PEU4, PEU5, PEU6
Perceived Control	6	PC1, PC2, PC3, PC4, PC5, PC6
Transaction Cost	5	TC1, TC2, TC3, TC4, TC5
Attitude toward APL	4	ATT1, ATT2, ATT3, ATT4
Intention to Us	7	INT1, INT2, INT3, INT4, INT5, INT6, INT7

The Cronbach's alpha coefficients range from 0.803 to 0.898. all these alpha coefficients are greater than 0.7, which is the minimum cut off value (Y. Chen et al., 2018), the result indicate good reliability, therefore, this questionnaire was reliable.

Data were obtained through web-based survey during January 2021. Total 530 questionnaires were sent to both offline and online channels via google form. For online survey, it has advantages for example, it minimizes missing data and reduce interviewer effect that might influence answer.

Table 14: Reliability Statistics with 42 items questionnaire

Measurement Items	Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
Trialability	.815	.816	5
Perceived Usefulness	.863	.863	9
Perceived Ease of Use	.803	.817	6
Perceived Control	.834	.837	6
Transaction Cost	.809	.810	5
Attitude toward APL	.856	.859	4
Intention to Us	.866	.865	7

Sampling Techniques and Sample Size

Selecting appropriate sampling is important to ensure the reliability of results in the study. Sampling approaches can be classified into probability and non-probability (J. Hair, Celsi, Money, & Samouel, 2016). Cluster technique was used to reach the target sample for the following reasons: the nature of the research, available resources, the purpose of the research, and time and cost. With this technique, it allows to have generalizability of the finding of entire population. Second, given the large and dispersed population, using alternative method to manage would have complicated the data collection process and may have necessitated extensive communication and travel. The sample frame was constructed primarily to target cluster in Bangkok area, with age between 18-60 years old, in which they have independent mobility and can make their own decision. The clusters used are students and employed respondents.

Sample size strategy was used to be published table (Israel, 1992). This method provides necessary combinations of precision, confidence levels and

variability as shown below in table 15. Therefore, the size of population here in this study is greater than 100,000, therefore with 5% precision, the obtained responses should be 400. The sample were screened to those that have online shopping experience in the past 3 months and live in Bangkok. In this survey, item completion rate was high, 100% as all respondents have to answer all questions in order to submit the responses.

Data cleaning was performed to exclude the responses that have extremely low and extremely high, as they are consider as outlier. After data cleaning, there were 500 responses qualified, as some had not shopped online in the past 3 months. The web-based sample was considered appropriate for this study for the reason of healthy and security concern during COVID19 pandemic situation and respondents are familiar with self-check/self-service technology which is aligned with the study objective (H.-J. Lee et al., 2010).

Structural Equation Model

In this study, Structural Equation Model (SEM) is used. It is referred as Covariance Structural Analysis, equation system analysis, and analysis of moment structures. There are various software available for SEM such as AMOS (Analysis of Moment Structures), LISREL (linear Structural Relations), and EQS (Equation System) (NAIR, 2012). In this study, AMOS is used carry out SEM.

The primary objective of SEM analysis is to confirm hypotheses about the observed means, variance and covariances of a set of variables. Number of structural parameters are used to represent hypotheses (eg. Factor loading, regression paths) that is smaller than the number of observed parameters. Path diagram is also used to represent SEM, in which it is a summary of theoretical relationships among latent variables and indicator variables and indicate directional (regression) and non-directional (correlational) relationships among latent variables. The arrow in SEM shows hypothesized relationships based on theory and previous research.

Table 15: Sample Size table

Size of Population	Sample Size (n) for Precision (e) of:			
	±3%	±5%	±7%	±10%
500	a	222	145	83
600	a	240	152	86
700	a	255	158	88
800	a	267	163	89
900	a	277	166	90
1,000	a	286	169	91
2,000	714	333	185	95
3,000	811	353	191	97
4,000	870	364	194	98
5,000	909	370	196	98
6,000	938	375	197	98
7,000	959	378	198	99
8,000	976	381	199	99
9,000	989	383	200	99
10,000	1,000	385	200	99
15,000	1,034	390	201	99
20,000	1,053	392	204	100
25,000	1,064	394	204	100
50,000	1,087	397	204	100
100,000	1,099	398	204	100
>100,000	1,111	400	204	100

a = Assumption of normal population is poor (Yamane, 1967). The entire population should be sampled.

3.4 Analysis Methodology for Environmental impact from APL Adoption

The objective of this study is also to assess carbon emission generated from different scenario of APL adoption. As this assessment was in general and, to the author's knowledge, had not been studied earlier, as well as a lack of data, a comparative method was chosen. The approach involved the use of data from previous literature reviewed, and statistical data from outsource providers in Thailand. The data was collected from several sources both national statistics, outsource reports and literature reviews. Comparative methods are used to compute environmental impact from using APL. The indicator that is used to assess the impact is Carbon emission which is widely used in many studies (Durand & Gonzalez-Féliu, 2015; Edwards, McKinnon, Cherrett, et al., 2009; Giuffrida et al., 2012; Hofer et al., 2019; Spijkerman, 2016; P. van Loon et al., 2014).

The parameters in the analysis are as follows and Table 16 summarize parameter for estimation Environmental impacts.

Number of Parcel delivered per day

According to the Economic Intelligence Center of SCB, the number of parcels delivered every day in Thailand in 2020 will be at least 4 million (Kamolmarn Jaenglom & Tantipidok, 2020).

APL Adoption Rate

The percentage of customers who choose APL as alternative to Home delivery for the first time delivery, the percentage varies from 5.5% to 20% (Yuen et al., 2018). In this study, 10% is used referred from moderate rate from (Morganti, Seidel, et al., 2014).

Number and Density of delivery addresses

The number and density of delivery addresses have a considerable impact on the carrier's time and distance. A study by McLeod et al. (2006) yielded 50 delivery drops and addresses.

Delivery failure Rate

While no data on the fraction of redeliveries that would potentially fail was published, the research employed a 10% first-time delivery failure rate. The failure rate is used to assess the results' sensitivity. Furthermore, the failure rate assumption in this analysis is that it will be replaced with a 10% adoption rate.

Number of collection and delivery points

Both carriers and customers' travel are influenced by the number of APL in a given area. The smaller the average consumer travel distance, the bigger the number of APL. The analysis employs one APL per delivery routing since the majority of consumers will utilize an APL that is close to their home or workplace, according to

the questionnaires obtained. As a result, the neighboring drops are presumed to be represented by the routing.

Carrier distance

As the number of deliveries to be made rises, carrier distance increases for the existing delivery mode (Home delivery). With the higher percentage of redelivery or failed delivery, the distance will be greater. The distance is assumed to be around 100km per routing day according to (McLeod et al., 2006) best case scenario.

CO_2 emission for km distance tour

From a study to quantifying CO_2 from (Edwards, McKinnon, Cherrett, et al., 2009), carbon emission was modelled for a standard home delivery round. It assumed average carbon emission from different vehicle, where van is assumed to be used for delivery for every carrier. The emission is in average 251 g/km (Spijkerman, 2016).

Table 16: Parameter for Carbon Emission Assessment

Parameters	Unit		source
Average carrier distance per day	100	km	McLeod et al. (2006)
Average drops per day	50	drops	
Average CO_2 per first time delivery drop	251	g CO_2/km	(Spijkerman, 2016)
Number of parcel delivered/day	4,000,000	parcels	(Kamolmarn Jaenglom & Tantipidok, 2020)
APL Adoption rate	10%		(Morganti, Seidel, et al., 2014)
First time delivery failure rate	10%		(Goodchild & Ivanov, 2017)

To analyze carbon emission from parameters mentioned above, assumptions of the analysis were formed as below

- Failed delivery will be considered as a new delivery on the next tour
- APL adoption will remove “first time delivery failure”
- Vehicle used to deliver parcels is standard van
- One drop is for one parcel
- All APL drops/parcels in the same tour is at the same APL location

The estimation results and discussion are provided in the next chapter.

Chapter 4: Result Analysis and Discussions

This section covers three major parts: fist, Predictors of Probability using APL and second, it's factors influencing Intention to use APL. And the last one is environment impacts from APL adoption with Home delivery. For the first part, the results from descriptive and inference statistics across four topics: 4.1.1 sample characteristics, 4.1.2 Preference locations and APL characteristics for APL adoption, 4.1.3 Socio-demographic characteristics of APL adoption, 4.1.4 Predictors of probability using APL Results and Discussion.

For the second part, the results and discussions are separated into 4.2.1 Data source 4.2.2 Data analysis, 4.2.3 Descriptive statistics, 4.2.3 Correlation among variables and Multicollinearity, 4.2.5 Structural Model assessment and 4.2.6 Structural Model results and discussions. And the last part, 4.3 Environmental impact assessment.

4.1 Predictors of Probability to use APL

4.1.1 Sample characteristics

The sample includes 718 observations (Male 43.2% and female 56.8%) who lives in Bangkok. The participants ranged in age from 15 to 60 years old. The great majority of those who responded were between the ages of 26 and 35. Bachelor's degree holders accounted for 48.2 percent of the total. The majority of respondents (74%) are single. 69 percent of the participants said they had no prior experience with APL. According to the survey, the majority of respondents are full-time employees and students, with 40% and 27% respectively. Individual income is reported to be less than THB15,000 per month for 34% of respondents.

From behaviors perspectives, most respondents live in their personal housing/landed property (70.2%), follow by Condominium and apartment for 23% and others (which represent commercial building/townhouse- 6.7%). The majority of respondents live with their parents, with the remainder living alone (44.3 percent and 22% respectively). Other living arrangements include living with a spouse, staying with a spouse and children, and living with a large number of family members, all of

which account for around 11% of the population. The remaining respondents identified themselves as belonging to others, which reflected their extended family, with their parents and children accounting for 12.5% of the total. When respondents are asked if someone stays at home during the day, the percentages are nearly identical (54.3% and 45.7%). Almost 80% of respondents said they own a car, with 64.3%saying they drive to work daily basis, followed by 33% saying they take public transport, and the rest saying they ride in a carpool. Table 17 shows the demographic characteristics of respondents.

Table 17: Respondents Characteristics

Characteristics	Observations	Percentage
Gender	Male	43.2
	Female	56.8
Age	<18 years	5
	18-25 years	30.9
	26-35 years	44.8
	36-45 years	16.7
	> 46 years	2.5
Marital status	Single	74.1
	Married	25.9
Education level	lower than Bachelor degree	12.5
	Bachelor degree	48.2
	Master degree	35.1
	PhD	4.2
Occupation	Students	25.9
	Full time employees	43.5
	Freelance	8.4
	Business Owner	11.7

Characteristics	Observations	Percentage
	Government official	5.6
	Unemployed	4.2
	others	0.8
Individual income (THB)	<15,000	34.3
	15,001-30,000	19.2
	30,001-45,000	16.4
	45,001-60,000	12.5
	>60,000	17.5
Type of accommodation	Residential	70.2
	Condominium	14.2
	Apartment	8.9
	others	6.7
Frequently purchased products	Cloths, Accessories, Cosmetics	44.7
	Grocery	20.9
	IT and accessories	28.8
	others	5.6
Household living	Stay alone	22.3
	stay with parents	44.3
	stay with spouse	10.9
	stay with spouse and child/children	10
	others	12.5
Online shopping experience	< 1 years	7.5
	1-3 years	25.9
	> 3 years	66.6
Online shopping frequency	once a month	25.1

Characteristics	Observations	Percentage
	2-4 times/ month	39.3
	> 4 times / month	35.7
Number of hours using Internet per day	Less than 2 hours	0.8
	2-5 hours	26.7
	more than 5 hours	72.4
product purchased	Clothing/ cosmetic	44.7
	Electronics/ IT accessories	20.9
Household car ownership	Yes	79.1
	No	20.9
Home internet access	Yes	87.5
	No	12.5
Commute/travel mode	Private car	64.3
	Public transport	33.1
	others	2.5

4.1.2 Preference of APL location and its characteristics

The most frequently mentioned type of locations that respondents are willing to get their parcel are shopping mall as reported for 44.6% of the observation, followed by supermarket, and public transportation for 15% and 8.6% respectively. Convenient stores and post offices were rated at the same frequency, which is 7.2%. other locations are presented in the figure 7. The results are similar to other researches. Kedia et al. (2017) showed that consumer's preferences for each of the types of business being use for APL. Supermarkets have highest preference, followed by petrol stations, dairies, pharmacies, and post shops. This was the reason from the frequency of visits which might be different in Bangkok contexts, where people usually go to shopping mall for dining and groceries shopping at the same time as supermarkets are also attached in shopping malls. Similar to Lachapelle et al. (2018)

study that showed top 5 locations of collection and delivery points in Brazil, which are drug stores, gas stations, post offices, supermarkets, and malls. The study from revealed that the major pickup point network is with tobacco shop, stationary/bookshop, local supermarkets and florist. While the highest number of location of collection points from (Weltevreden, 2008) were supermarkets, followed by office supplies & book stores, post office, gas station. In additions, majority of the locations are in city centers, followed by village center, and neighborhood center. While Kedia et al. (2017) stated that collection and delivery points are increased in CBD area. However, with the location preferences, this might have to take into account of income- population, job opportunity, population, main road and spatial pattern as these are reported to impact potential to serve more significant portion of users (L. K. d. Oliveira et al., 2019). The other study presented that the majority of the network rely primarily on small independent local shops (Morganti, Seidel, Blanquart, Dablanc, & Lenz, 2014).

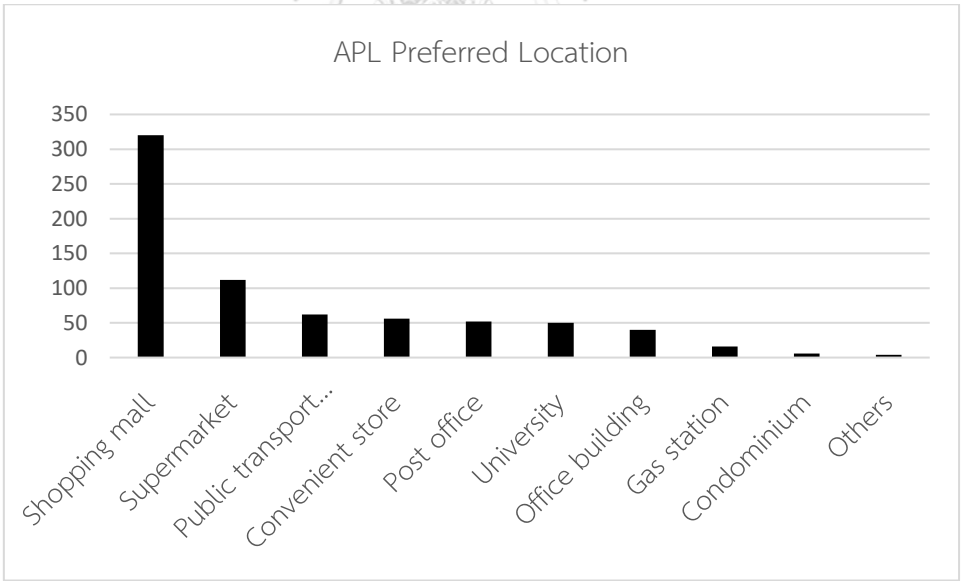

Figure 7: APL Preferred Location

Moreover, the respondents stated the advantages of the location facilities, which imply why they chose to to there to pickup parcels. Majority stated that they go there for shopping, which is aligned with the preferred location selected. This is

followed by having a meal, which are also done in shopping malls and supermarkets. Leisure and going to work are followed in the third and forth reason respectively. For others, it is explained for those sending family members to schools or another working place. The results are presented in figure 8.

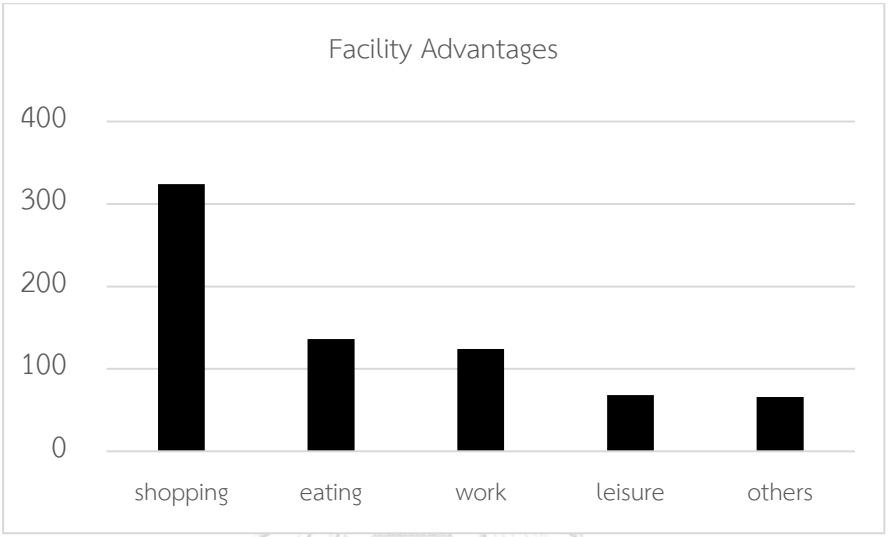

Figure 8: Facility Advantages

When respondents were asked about the reason why they choose a specific location, most of observations were reported that the reason was it was “near home”, which implies that the location must be in the residential area and this is similar to Iwan et al., (2016) that majority of the users indicated that they chose to use the station that close to their home. A study in New Zealand also showed that the pickup point should be adjacent to the customer's office or home to enhance accessibility for potential customers (Kedia et al., 2017). Almost 21% declared their preference for APL that it was along the way of their daily commute and almost 19% reported as it is near their office. This result aligned with the location preference which shows that office building and University are pointed out, apart from retail location group. The results show in figure 9.

For the service time (illustrated in figure 10) that respondents are going to take their parcels from APL are between 18.00-22.00 which are almost 50%, which

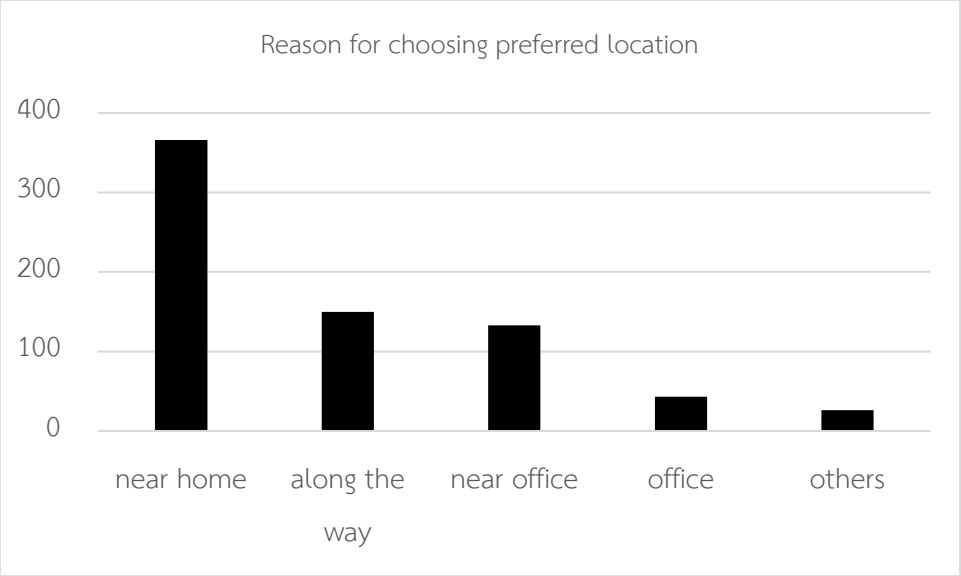

Figure 9: Reason for Choosing Preferred Location

implies that the respondents cannot wait to receive their parcel and need to take the parcel after working hours. This is similar to finding from Madlberger and Sester (2005) identifying that employed status prefer to get parcel delivered in the evening. The second most preferred is the service time between 10.00-18.00hr for 46%. The combination of the first and the second have around 96%. This implies that most of the potential users are not at home during the day, and the congestion of the usage will be between 10.00-22.00 hrs.

Figure 10: Service Time Preference

To complete the analysis related to APL location preference, respondents were asked to state precise location to identify travelling time and travelling distance from origin to APL location, google map is used to identify travelling distance and time. The results are presented in figure 11 and table 18

From figure 11, 48.2% indicated that they would prefer APL location that is between 1-5km to travel with average traveling time of 7 mins. The second preferred location is 5-10km with average of 17 mins for travelling time, following by less than 1 km which has 6 minutes as average travelling time. In conclusion, over 80% of respondents prefer to access APL within 10km by 17 minutes in average. These findings are similar to many studies that most of the users/customers are willing to use APL when the traveling distance is not more than 10 km with traveling time not more than 20 minutes (Hofer et al., 2019; Morganti, Dablanc, & Fortin, 2014; Morganti, Seidel, et al., 2014; L. K. d. Oliveira et al., 2017; L. K. d. Oliveira et al., 2019; Weltevreden, 2008). A research conducted in France and Germany showed that the nearest point is located 1.6 km in urban area and 6km in rural area (Morganti, Seidel, et al., 2014), while majority of population can access pickup point by 5 minutes.

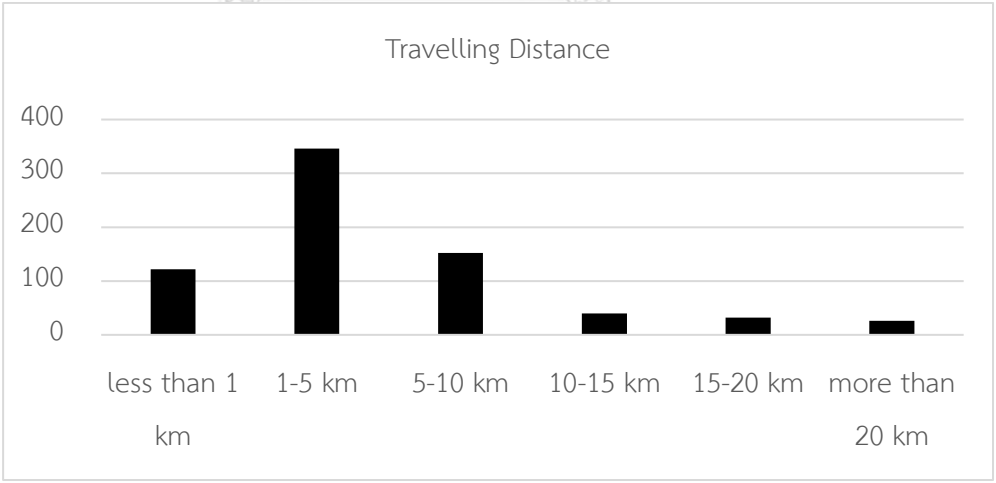

Figure 11: Travelling Distance

Table 18: Travelling Distance and Average travelling time

Travelling Distance (km)	Average Travelling time (minute)	Frequency	%
less than 1	6.04	122	17.0%
1-5	10.21	346	48.2%
5-10	17.00	152	21.2%
10-15	24.2	40	5.6%
15-20	32.87	32	4.5%
more than 20	53.54	26	3.6%

4.1.3 Socio-demographics characteristics of parcel locker adopters.

To understand and determine the defaces in probability to use APL between groups, Independent sample T-test and one-way ANOVA were used to analyze. SPSS software has been used for the analysis; the results are summarized in table 19. The variables that are statistically significant different are Age, Education, Income, Occupation. The rest of the variable have no significant difference.

Age is statistically significant different. When comparing age group of respondents, the result shows that probability to use APL in age group “less than 18 years” is statistically different from 26-35 years in which the first age group has higher probability. This would be the reason of not being at home by young population, comparing to 26-35 years group which their time is tied with work. This is similar to a study in Australia which indicated that under education prefer to have pickup point (Madlberger & Sester, 2005).

Education is statistically significant different between group, where the group of lower than Bachelor degree is statistically significant different from Master degree and PhD. This is concluded that the probability to use APL in Lower than bachelor’s degree group is higher than in Master and PhD. The result also shows that in group of Graduate, the probability to use APL is also higher than in PhD group. This is aligned with the first finding with age which indicated the younger group tend to use APL

more than older one. While this is different from Weltevreden (2008) which showed the result that medium education tend to use pickup point.

On **income** perspective, it shows the difference between range of individual income, in which individual income of lower than THB15,000 is significant different from individual income between 30,001-45,000. The result shows that the probability to use APL in people who have income lower than THB15,000 is higher than THB30,0001-45,000. The percentage average of probability to use APL by income also showed that the lowest range (<15,000 THB) has highest probability to use APL. This is aligned with the findings above which indicating that the age of <18 years old and undergraduate tend to use APL more than another group.

From **Occupation,** T-test are employed. The results showed that between group of students and non-students, they are significant different in probability to use. This indicating that the group of student tends to use APL more than non-student group. While between Full-time employees and non-full-time employees, they are also significant different in probability to use APL, in which non-full time employees tend to use APL more than full-time group. This is the same as from a study from Madlberger and Sester (2005) which It was revealed that one's employment position has no bearing on the way of delivery (pickup point).

So, from the overall results in this section, it can be concluded that those who are students, age below 18 years old, undergraduate education level with low income tend to use APL.

Table 19: ANOVA Result

(a)

Age	Mean	<18 years	18-25	26-35	36-45	>45
< 18 years	1.896		1.584	1.654*	1.1644	-0.4968
18-25	0.3127			0.070	-0.419	-2.081
26-35	0.2427				-0.489	-2.151
36-45	0.7322					-1.661
46-55	2.393					

(b)

Education	Mean	lower than bachelor	graduate	master	PhD
Lower than bachelor	1.545		.878	1.508*	2.633*
Graduate	0.667			.630	1.755*
Master	0.037				1.125
PhD	-1.087				

(c)

Income	Mean	<15,000	15,000-30,000	30,001-45,000	45,001-60,000	>60,000
<15,000 THB	0.943		0.597	1.141*	0.711	0.392
15,000-30,000	0.346			0.544	0.114	-0.205
30,001-45,000	-0.198				-0.43	-0.749
45,001-60,000	0.232					-0.319
>60,000	0.551					

Table 20: Summary result of Socio-demographics characteristics for the APL adoptions

Variable		**Mean**	**SD**	**Sig.**
Age	<18 years	1.897	3.057	0.005*
	18-25 years	0.313	3.057	
	26-35 years	0.243	3.057	
	36-45 years	0.732	3.057	
	>45 years	2.393	3.057	
Marital status	Single	0.633	3.358	0.680
	Married/living together	0.017	3.425	

Variable		Mean	SD	Sig.
	others	1.764	3.425	
Education level	lower than Bachelor	1.545	3.750	0.001*
	Bachelor	0.668	3.188	
	Master	0.037	3.444	
	PhD	-1.087	3.376	
Individual income (THB)	<15,00	0.943	2.864	0.047*
	15,001-30,000	0.471	3.952	
	30,001-45,000	-0.387	4.006	
	45,001-60,000	0.839	3.067	
	>60,000	0.350	3.173	
Gender	Male	0.547	3.345	0.663
	Female	0.435	3.450	
Occupation: Student	No	0.342	3.619	0.036*
	Yes	0.870	2.695	
Occupation: Full-time employee	No	0.724	3.145	0.025*
	Yes	0.123	3.732	
Occupation: Freelance	No	0.431	3.429	0.172
	Yes	1.058	3.075	
Occupation: Business owner	No	0.435	3.367	0.303
	Yes	0.843	3.660	
Occupation: Civil servant	No	0.504	3.421	0.584
	Yes	0.248	3.202	
Occupation: Retired	No	0.472	3.384	0.588
	Yes	1.764	5.467	
Occupation: Unemployed	No	0.521	3.398	0.060
	Yes	-1.004	3.341	
Occupation: others	No	0.487	3.396	0.829
	Yes	0.487	3.972	

4.1.4 Predictor of Probability to use APL

According results from multiple linear regression analysis from IBM SPSS Statistics 22, Table 21, 22 and 23 showed all significant coefficients, and marginal effects. The general fit of the model was evaluated using the adjusted R^2, reported as 0.313. with similar research, the variance explained by independent variable are between 15%-38% (C. Liu et al., 2019; L. K. d. Oliveira et al., 2017). Gender is a socio-demographic factor that influences the probability of adoption; females are much less likely than males to adopt APL, and the probability is reduced by 6.5% if the users are female. According to Morioka, (2014), the study showed that the key in perception of technology adoption is gender. Moreover, Men is indicated that they are likely to use IT more than women for practical purposes (Wells & Chen, 1999). The result from J. W. J. Weltevreden (2008) is different which showed the female has higher adoption and age is significant (Mitrea et al., 2020). From Bangkok context, this might be from the reason of the convenience of travelling and the availability of transportation facility which limit women to travel.

Table 21: Model Summary and F-Test

(a)

R	R Square	Adjusted R Square	Std. Error of the Estimate
.579[ac]	.335	.313	2.821

(b)

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	2780.004	23	120.870	15.18905	.000[ad]
Residual	5522.635	694	7.958		
Total	8302.639	717			

Varied age groups were shown to have diverse impact; for example, age 18-25 has a negative effect on the probability of using APL, whereas age groups over 45 have a positive impact, with a 30 percent increased probability of using APL when

compared to age under 18. This is noteworthy because some studies suggests that the elderly are interested in self-service technologies (Brummelman, Kuipers, & Vale, 2003; Weltevreden, 2008). However, different age range was mentioned. In this study, age over 45 has higher probability using APL while age over 66 was mentioned in previous study. Other studies showed that young people tend to use parcel locker more (Lemke et al., 2016). This is contradicted as people at age 18-25 years that show negative impact on probability using APL, comparing to below 18 group. As mentioned in the previous chapter, this might relate to the fact that those group of age is tied with work and has no time to go out to pick up parcels. While Those over 45 may have more freedom to go and have more time as the position or status are more mature than younger people.

In terms of income, the range of 30,001 THB to 45,000 THB has a negative effect on the probability of using APL; this range of income reduces the probability of using APL by 12% on average, compared to those with income less than THB 15,000. As a result of those income levels, which are generally full-time employees with a tight schedule during the day or who may be able to acquire the parcel by another means, the probability of use may be impacted. While income is not statistically significant in one study, it is in another (Lachapelle et al., 2018; J. W. J. Weltevreden, 2008). When compared to the students' group, full-time employees and unemployed have a negative effect on the probability of using APL by 8.4% and 17.5%, respectively, because full-time jobs have strict schedules and unemployed are those who stay at home and have no difficulty with home delivery.

Other types of dwelling, such as residential unit/townhouse and condominium/apartment, have a significant favorable effect on the probability of using APL, increasing by 31.9 percent and 16.7 percent, respectively, if users live in such categories. This conforms with Lachapelle et al. (2018) found that the type of house classified as Apartment is statistically significant. The cause could be that no one receives the parcel when it comes, due to the fact that the juristic office's working hours are limited, similar to those of a condominium or office building. People who live with their parents have a 14 percent higher chance of using APL, because they are generally young adults (26-35 years old), and in Thai culture, young

adults still live with their parents. When someone is at home during the day, however, the probability of utilizing APL drops by 9%, because they don't have to worry about the parcel being returned if it isn't delivered.

People who have shopped online for more than a year have a 28 percent lower probability than those who have shopped online for less than a year, according to their shopping online experience. This differs from J. W. J. Weltevreden (2008), who claims that the richer the customer's experience with online purchasing, the less likely they are to modify their behaviors and preferences.

This could be why, because APL is a new service, consumers who are accustomed to one mode of distribution are less likely to adjust and adjust to a new mode of delivery. When it comes to internet buying frequency, persons who purchase online frequently have a 21 percent higher chance of adopting APL. From the amount of hours spent on the internet, the longer the time spent on the internet, the higher the probability (Mitrea et al., 2020). Customers who utilized the internet for more than 5 hours per day increased their likelihood of using APL by 7.5 percent, according to the results.

In addition, the probability of using APL decrease by 10% when people have their own car. This might be from the reason that those people may not be constrained by home-delivery method as their income tend to be above average. This differs from a study by Lachapelle et al. (2018) and Liu, Wang, & Susilo (2019) which found that those who drive use APL more than those who don't. According to reports, those people are forced to travel longer distances to pick up their packages, and they are less likely to utilize APL.

On preference aspects, when the discount price increase the probability using APL by 31%. The result is similar to a study from L. K. d. Oliveira et al. (2017) and Kedia et al. (2017). Those previous studies showed that discount or different pricing from delivery channels positively impact on probability of using this service, including incentive which becomes significant factor. In terms of choice locations, shopping malls have a negative impact on probability, reducing the likelihood of convenient stores by 7%. Though this is the most preferred location from the previous section, it is not significant positive impact probability to use. Potential reasons are as

followings. First, customers might not want to specify the time visiting shopping more as this is more emotional rather than rationale behaviors. Second, the distance to shopping mall may be off their way home or office, and this needs additional effort to travel to. While the likelihood of utilizing APL is increasing by 38% in condominiums and 15% in office buildings, respectively. As expected, this might be from the corporate policy in some organizations that prohibit employees to use company's address as a delivery address. In addition, working hours are limited to 7pm-8pm, in which the juristic office opens. As a result, several renters are unable to contact them in time to receive their goods. The result of the resident areas and working place are similar to other findings from McLeod et al., (2006), Kedia et al., (2017), and Junjie & Min (2013). Lastly, despite its tiny size, distance reduces the probability of adopting APL by 0.5%, which is similar to Liu, Wang, & Susilo (2017) but reported as different probability impact. Moreover, the proabiliyt of using APL decrease by 10% when there is someone at home during the day.

Table 22: Parameter estimates for Probability of APL Adoption

Model		Unstandardized Coefficients		t	Sig.	Collinearity Statistics
		B	Std. Error			VIF
	(Constant)	.942	.529	1.781	.075	
Gender	Female	-.536	.235	-2.275	.023	1.227
Age	18-25	-1.087	.285	-3.816	.000	1.565
	> 46	2.769	.719	3.852	.000	1.139
Education	PhD	-1.052	.368	-2.856	.004	1.095
Individual income	THB 30k-THB 45k	-.965	.303	-3.185	.002	1.138
Occupation	Full-time employee	-.688	.246	-2.800	.005	1.339
	unemployed	-1.437	.578	-2.485	.013	1.209
Own a car	Yes	-.825	.334	-2.472	.014	1.660
Household living	with spouse and child	1.020	.400	2.553	.011	1.300
	with parents	1.698	.272	6.251	.000	1.642
Type of Accommodation	other type of house	2.619	.479	5.470	.000	1.290
	Condominium/apartment	1.369	.435	3.148	.002	1.386
Have someone stay home during the day	Yes	-.709	.237	-2.991	.003	1.257
experience Shopping online	1-3 years	2.594	.532	-4.875	.000	4.903

Model		Unstandardized Coefficients		t	Sig	Collinearity Statistics
		B	Std. Error			VIF
	more than 3 years	2.084	.518	-4.022	.000	5.392
Frequency of shopping online	2-3 times/month	1.748	.338	5.174	.000	2.456
	4 or more times/month	1.703	.353	4.826	.000	2.577
hours using internet	more than 5 hours	.613	.255	2.407	.016	1.171
APL Location Preference	Shopping mall	-.535	.228	-2.349	.019	1.155
	Office Building	1.046	.491	2.131	.033	1.143
	Condominium	4.062	1.194	3.401	.001	1.067
Travelling distance	distance	-.045	.018	-2.510	.012	1.085
Price set	Discount	2.539	.211	12.053	.000	1.001

Table 23: Marginal Effect

Model		Marginal Effects			
		dy/dx	SD	Min	Max
	(Constant)				
Gender	Female	-.065	.055	-.134	-.003
Age	18-25	-.132	.112	-.272	-.005
	> 46	.337	.286	.014	.692
Education	PhD	-.128	.109	-.263	-.005
Individual income	THB 30k-THB 45k	-.118	.100	-.241	-.005
Occupation	Full time Employee	-.084	.071	-.172	-.003
	Unemployed	-.175	.149	-.359	-.007
Own a car	Yes	-.100	.085	-.206	-.004
Household living	with spouse and child/children	.124	.105	.005	.255
	with parents	.207	.176	.008	.424
Type of Accommodation	Other type of house	.319	.271	.013	.655
	Condominium/Apartment	.167	.142	.007	.342
Have someone stay home during the day	Yes	-.086	.073	-.177	-.004
Experience Shopping online	1-3 years	-.316	.268	-.648	-.013
	more than 3 years	-.254	.215	-.521	-.010
Frequency of shopping online	2-3 times/month	.213	.181	.009	.437
	4 or more times/month	.208	.176	.008	.426
Hours using internet	more than 5 hrs	.075	.063	.003	.153
APL Location Preference	Shopping mall	-.065	.055	-.134	-.003
	Office Building	.127	.108	.005	.261
	Condominium	.495	.420	.020	1.016
Travelling distance	Distance to APL	-.005	.005	-.011	.000
Price set	Discount	.309	.262	.013	.635

4.2 Factors influencing Intention to use APL

This part aims to explain the factors influencing Intention to use APL in Bangkok to covers 4.2.1) Data source 4.2.2) Data analysis 4.2.3) Model testing: Structural Regression model and 4.4.4) Hypothesis tests and Discussions

4.2.1 Data source

The participants of the survey were 500 responses, in which there were 39.6% of male and 60.4% of female. While 73% are single and the rest are married. Among the respondents, the highest age group was age between 26-35, which is accounted for 34.4%, followed by age group of 18-25, 36-45, 46-55, and more than 55 respectively (34.2%, 24.6% 6% and 1%).

For individual income, the majority of the Reponses are having an individual income less than THB 15,000. Where the majority of respondents have education level below bachelor degree (41%) and individual income less than THB 15,000 (36.8%), followed by THB 15,000-30,000 range, which is almost 28%. From occupation aspect, the highest percentage is full time employee, almost 55%, followed by student (34%). Table 24 shows demographic data for the respondents.

Table 24: Demographic of respondents for Intention to use APL

Demographic		Percentage
Gender	Male	39.6
	Female	60.4
Age	18-25	34.2
	26-35	34.4
	36-45	24.6
	46-55	5.8
	>55	1.0
Marital Status	Single	72.8
	Married	27.2
Occupation	Student	34.0
	Full time Employee	54.4

Demographic		Percentage
	Retired	1.8
	Freelance	4.8
	Business owner	5.0
Individual income	less than 15k	36.8
	15k-30k	27.4
	30k-45k	18.2
	45k-60k	7.6
	more than 60k	10.0
Education	lower than Bachelor degree	47.4
	Bachelor degree	35.8
	Master degree	10.8
	PhD	6.0

Among the respondents, there are 50 respondents had experience with APL. There is 36% male and 64% female. Majority of them are between 18 years old to 35 years old. Most of them are students and full-time employees with income less than THB15,000 per month and between THB15,001-THB30,001.

Other respondents who do not have experience were instructed by the questionnaires instructions that explained and guide them What APL and how to use it.

4.2.2 Data analysis

In this study, the skewness and Kurtosis values were examined. Skewness is a measure of a distribution's symmetry, whereas Kurtosis is a measure of the peakedness or flatness of a distribution (Hair, 2009). Those indices were computed in large scale sample. When Skewness and Kurtosis are zero, it shows that distribution is perfectly normal. While minor deviations from zero are insignificant, particularly for a large sample size (N≥200), significant deviations should be taken into account. The

cut-off value of skewness and kurtosis should be within +1 to −1 range when the data is normally distributed. However, Hair et al. (2009) suggests a more lenient measure of +3 to −3. Skewness and Kurtosis values for the items in this study ranged from -0.884 to 0.181 for Skewness and -0.785 to 0.622 for Kurtosis, as shown in table 25 and table 26.

Table 25: Assessment of Normality

Variable	skew	c.r.	kurtosis	c.r.
TRIAL1	-0.283	-2.583	-0.759	-3.464
TRIAL3	-0.203	-1.855	-1.053	-4.804
TRIAL5	-0.522	-4.768	-0.268	-1.224
PEU1	-0.469	-4.282	-0.588	-2.686
PEU2	-0.373	-3.407	-0.848	-3.87
PEU4	-0.464	-4.237	-0.561	-2.559
PU1	-0.629	-5.745	-0.248	-1.131
PU2	-0.762	-6.957	0.094	0.43
PU3	-0.741	-6.761	-0.015	-0.067
PU5	-0.445	-4.062	-0.525	-2.397
ATT1	-0.353	-3.221	-0.891	-4.068
ATT2	-0.613	-5.593	-0.223	-1.018
ATT3	-0.334	-3.048	-0.706	-3.22
ATT4	-0.315	-2.878	-0.8	-3.649
PC1	-0.7	-6.39	-0.315	-1.436
PC3	-0.453	-4.136	-0.637	-2.906
PC6	-0.492	-4.489	-0.655	-2.991
TA2	-0.18	-1.644	-1.264	-5.77
TA4	-0.376	-3.432	-0.457	-2.086
TC2	-0.55	-5.025	-0.204	-0.932
TC3	-0.25	-2.286	-0.923	-4.213
INT2	-0.261	-2.383	-0.936	-4.273

Variable	skew	c.r.	kurtosis	c.r.
INT5	-0.417	-3.806	-0.68	-3.105
INT6	-0.645	-5.885	-0.256	-1.17
INT7	-0.546	-4.985	-0.458	-2.093

Table 26: Mean and standard deviation of each observed variable

Variable	N	Mean	Std. Deviation
TRIAL1	500	4.10	.738
TRIAL3	500	4.11	.739
TRIAL5	500	4.08	.829
PEU1	500	3.90	.943
PEU2	500	3.96	.901
PEU4	500	3.94	.888
PU1	500	4.14	.807
PU2	500	4.08	.861
PU3	500	4.14	.842
PU5	500	4.11	.778
ATT1	500	4.06	.828
ATT2	500	3.96	.932
ATT3	500	3.97	.839
ATT4	500	3.93	.880
PC1	500	4.25	.778
PC3	500	4.10	.809
PC6	500	4.20	.755
TA2	500	4.04	.829
TA4	500	4.01	.811
TC2	500	4.11	.799
TC3	500	3.96	.855
INT2	500	3.92	.890
INT5	500	3.94	.894

Variable	N	Mean	Std. Deviation
INT6	500	4.17	.799
INT7	500	3.99	.900

4.2.3 Descriptive Statistics

Respondents were asked to rate their overall agreement/disagreement from 1 (Strongly disagree) to 5 (Strongly agree). Of all the responses (n=500), Trialability has 16.6% rated as 3 out of 5, 55.6% rate 4 out of 5 and 27.8% rate 5. This showed that majority of the respondents' rate 4 and reported that they agreed that they would use APL if they had a chance to try on this service.

On Perceived Ease of use, frequency and percentages are presented that 3.6% rated 2 out of 5, 24.8% rated 3 out of 5, 45.4% rated 4 out of 5, and 26.2% rated 5. This result showed that most responses rated 4, which means that they agreed that using APL is convenient and easy to use and understand how to use it. In addition, on Perceive usefulness, 13.8% rated 3 out of 5, 50.4% rated 4 out of 5, and 35.8% rated 5. Most responses rated 4 which explained that they agreed that APL is useful in terms of reducing emission, faster than home delivery and reduce lost and damaged parcels. From Attitude perspective, 0.4% rated 2 out of 5, 19.6% rated 3 out of 5, 51.2% rated 4 out of 5, and 28.8% rated 5. This can be concluded that the majority agreed that they feel good about using APL, increase their convenience and providing faster service.

On Perceived control, 0.4% rated 2 out of 5, 11.4% rated 3 out of 5, 56.2% rated 4 out of 5 and 32% rated 5. This percentage concluded that the majority agree that they feel that they have control over the place they want to pick up parcel and control their traveling objective to pick up.

From Technology anxiety, the frequencies and percentages concluded that 0.2% rated 2 out of 5, 14.2% rated 3 out of 5, 48.4 rated 4 out of 5, and 37.2 rated 5 out of 5. This showed that the majority agree that they feel in confident and afraid that they will not be able to use APL. This is quite similar to Transaction cost, where the majority agree that they need to use a lot of effort to go to pickup their parcel

which is accounted for 49.4% with 4 rating out of 5, where 1% rated 2, 12.4% rated 3, and 37.2% rated 5. Table 27 illustrated descriptive statistics of each factor.

Table 27: Means and Standard Dation For All Variables

(a)

Statistics								
		TRIAL	PEU	PU	ATT	PC	TA	TC	INT
N	Valid	500	500	500	500	500	500	500	500
	Missing	0	0	0	0	0	0	0	0
Mean		4.11	3.94	4.22	4.08	4.20	4.23	4.23	4.12
Std. Deviation		.658	.807	.670	.703	.642	.687	.696	.684

(b) Trialability

		TRIAL 1	TRIAL 3	TRIAL 5
N	Valid	500	500	500
	Missing	0	0	0
Mean		4.10	4.11	4.08
Std. Deviation		.738	.739	.829
Variance		.545	.545	.688
Minimum		2	2	1
Maximum		5	5	5

(c) Perceived Usefulness

		PU1	PU2	PU3	PU5
N	Valid	500	500	500	500
	Missing	0	0	0	0
Mean		4.14	4.08	4.14	4.11
Std. Deviation		.807	.861	.842	.778
Variance		.651	.741	.709	.606

	PU1	PU2	PU3	PU5
Minimum	2	1	1	2
Maximum	5	5	5	5

(d)Perceived Ease of Use

		PEU 1	PEU 2	PEU 4
N	Valid	500	500	500
	Missing	0	0	0
Mean		3.90	3.96	3.94
Std. Deviation		.943	.901	.888
Variance		.889	.812	.788
Minimum		1	2	2
Maximum		5	5	5

(e) Attitude

		ATT 1	ATT 2	ATT 3	ATT 4
N	Valid	500	500	500	500
	Missing	0	0	0	0
Mean		4.06	3.96	3.97	3.93
Std. Deviation		.828	.932	.839	.880
Variance		.685	.868	.705	.774
Minimum		2	1	2	2
Maximum		5	5	5	5

(f) Perceived Control

		PC 1	PC 3	PC 6
N	Valid	500	500	500
	Missing	0	0	0
Mean		4.25	4.10	4.20
Std. Deviation		.778	.809	.755

	PC 1	PC 3	PC 6
Variance	.606	.654	.570
Minimum	2	2	2
Maximum	5	5	5

(g) Technology Anxiety

		TA 2	TA 4
N	Valid	500	500
	Missing	0	0
Mean		4.04	4.01
Std. Deviation		.829	.811
Variance		.688	.657
Minimum		2	1
Maximum		5	5

(h) Transaction Cost

		TC 2	TC 3
N	Valid	500	500
	Missing	0	0
Mean		4.11	3.96
Std. Deviation		.799	.855
Variance		.638	.732
Minimum		1	2
Maximum		5	5

(i) Intention to Use

		INT 2	INT 5	INT 6	INT 7
N	Valid	500	500	500	500
	Missing	0	0	0	0
Mean		3.92	3.94	4.17	3.99

	INT 2	INT 5	INT 6	INT 7
Std. Deviation	.890	.894	.799	.900
Variance	.792	.800	.638	.810
Minimum	2	2	2	1
Maximum	5	5	5	5

4.2.4 Correlation among variables and Multicollinearity

Pearson is a professor at the University of Correlations were performed to offer a preliminary assessment of the study's intricate interactions between variables. In table 28, bivariate correlations were shown among the variables. The results showed that the correlation among variables is between 0.49 to 0.66 which are consider as moderate correlation, according to Field (2005), this also concluded that all variables are statistically significant to each other.

Table 28: Correlations Among Variables (n=500)

Correlations

		1	2	3	4	5	6	7	8
1	TRIAL	1							
2	PEU	.604**	1						
3	PU	.642**	.671**	1					
4	ATT	.578**	.600**	.597**	1				
5	PC	.621**	.495**	.590**	.523**	1			
6	TA	.663**	.541**	.602**	.494**	.577**	1		
7	TC	.609**	.526**	.558**	.547**	.535**	.659**	1	
8	INT	.617**	.630**	.613**	.821**	.553**	.576**	.562**	1

** Correlation is significant at the 0.01 level (2-tailed).

Multicollinearity

The degree to which the influence of any variable may be predicted or accounted for by the other variables in the study is referred to as multicollinearity (J.

F. Hair, 2009). Inter-correlations across items in this study range from 0.214 to 0.542, as shown in table 29. As a result, there was no concern with multicollinearity because these values did not exceed the crucial value of 0.90 (Kline, 2005).

4.2.5 Structural Regression Model Assessment

We begin to study the structural mode after determining the measurement model with satisfactory result. To state the links between the constructs, structural Equation Modelling was used. This structural model helps illustrate precise details about the link between the variables by displaying the associations between the independent and dependent variables, which are referred to as exogenous and endogenous variables, respectively (J. F. Hair, 2009). The overall model fit, size, direction, and relevance of the calculated hypothesized parameter are all examined in this model. In the path diagrams, one-headed arrows are used to show the relationships. AMOS and the maximum likelihood estimate (MLE) approach were used to examine the model.

AMOS yields type of information that can be useful in detecting model misspecification (M.I.s)- modification indices. Thus, this evidence of misfit in this regard is captured by the M.I.s**.** The result of the structural model includes path loading, standardized regression weight, critical ratio, and p-value, shown in table 4.15. The test results of the structural model are shown in Figure 4.7 with unstandardized regression weight and Figure 4.8 shows standardized regression weight.

The Structural Regression Model was interpreted using a variety of criteria. A total fit of the hypothesized to the current study's data was used, and a variety of indices were investigated. There were CMIN/ DF, GFI, CFI, RMR, and RMSEA and their criteria presented in table 30.

Table 29: Correlation Among Items

	items	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	INT7	1																								
2	TC2	0.287	1																							
3	TC3	0.275	0.394	1																						
4	TA4	0.255	0.322	0.308	1																					
5	TA2	0.251	0.317	0.303	0.291	1																				
6	PC6	0.269	0.335	0.321	0.321	0.316	1																			
7	PC3	0.231	0.288	0.276	0.276	0.271	0.353	1																		
8	PC1	0.267	0.333	0.319	0.319	0.314	0.409	0.351	1																	
9	INT6	0.374	0.316	0.302	0.281	0.277	0.296	0.254	0.294	1																
10	INT5	0.336	0.284	0.272	0.253	0.249	0.267	0.229	0.265	0.370	1															
11	INT2	0.340	0.288	0.276	0.256	0.252	0.270	0.232	0.268	0.375	0.337	1														
12	TRIAL5	0.330	0.373	0.357	0.347	0.341	0.365	0.313	0.362	0.363	0.327	0.331	1													
13	TRIAL3	0.314	0.354	0.339	0.330	0.325	0.347	0.298	0.345	0.345	0.311	0.315	0.431	1												
14	PEU2	0.376	0.331	0.317	0.308	0.303	0.324	0.278	0.322	0.413	0.372	0.377	0.403	0.383	1											
15	PEU4	0.324	0.286	0.274	0.266	0.262	0.280	0.240	0.278	0.357	0.321	0.325	0.348	0.331	0.517	1										
16	PEU1	0.340	0.300	0.287	0.279	0.275	0.294	0.252	0.292	0.374	0.337	0.341	0.365	0.347	0.542	0.468	1									
17	TRIAL1	0.291	0.329	0.315	0.306	0.301	0.322	0.276	0.320	0.320	0.288	0.292	0.400	0.381	0.356	0.307	0.322	1								
18	PU2	0.308	0.295	0.283	0.275	0.271	0.289	0.248	0.287	0.339	0.305	0.309	0.360	0.342	0.374	0.323	0.339	0.317	1							
19	PU5	0.293	0.281	0.269	0.261	0.257	0.275	0.236	0.273	0.323	0.290	0.294	0.342	0.325	0.355	0.307	0.322	0.302	0.324	1						
20	PU3	0.296	0.284	0.271	0.264	0.260	0.278	0.238	0.276	0.326	0.293	0.297	0.345	0.328	0.359	0.310	0.325	0.305	0.327	0.311	1					
21	PU1	0.356	0.341	0.327	0.318	0.313	0.334	0.287	0.332	0.392	0.352	0.357	0.416	0.395	0.432	0.373	0.391	0.367	0.394	0.374	0.378	1				
22	ATT4	0.408	0.266	0.254	0.247	0.244	0.260	0.223	0.259	0.449	0.404	0.409	0.324	0.308	0.373	0.322	0.338	0.286	0.305	0.290	0.293	0.352	1			
23	ATT3	0.438	0.285	0.273	0.265	0.261	0.279	0.240	0.277	0.482	0.433	0.439	0.347	0.330	0.400	0.346	0.362	0.306	0.327	0.311	0.314	0.378	0.439	1		
24	ATT2	0.391	0.255	0.244	0.237	0.234	0.250	0.214	0.248	0.431	0.387	0.392	0.310	0.295	0.358	0.309	0.324	0.274	0.292	0.278	0.281	0.338	0.393	0.421	1	
25	ATT1	0.438	0.285	0.273	0.266	0.262	0.280	0.240	0.278	0.482	0.433	0.439	0.348	0.331	0.400	0.346	0.363	0.307	0.327	0.311	0.314	0.378	0.440	0.472	0.422	1

Table 30: Goodness of Fit and Results

Model Fit Criteria	**Name**	**Acceptable Threshold**	**Interpretation**	**Result**
X^2	Model Chi-square	p-value > 0.05	assess overall fit	0.11
CMIN/DF	Chi-square/ DF	≤3.5 to 0 (perfect fit)	assess overall fit and the discrepancy between sample and fitted covariance matrices	1.109
GFI	Goodness of Fit	≥0.9	the proportion of variance accounted for by the estimated population covariance.	0.957
NFI	(non) Normed Fit index	>0.95	indicates the model of interest improves the fit by 95% relative to the null model.	0.933
CFI	Comparative Fit Index	≥0.9	Compare the fit of a target model to the fit of an independent model	0.993
RMSEA	Root Mean Square Error of Approximation	≤ 0.08	a parsimony-adjusted index. Values closer to 0 represent a good fit.	0.015

The chi-square value was significant (194.115, p>0.05), indicating that the model anticipated relationships that differed considerably from those seen in the data. The normative chi-square score was 1.109, indicating a good match. GFI =0.965

consistently indicated an excellent fit of the model to the data, while NFI=0.941 suggested that interest improves the fit by 95% when compared to the null model. CFI =0.994 and RMSEA = 0.015 demonstrated a reasonably good fit of a target model to the fit of an independent model.

4.2.6 Result and Discussion

Hypothesis testing results are also shown in Table 32 and figure 14. Attitude (β = 1.061, p<0.01) has significant positive impact to intention to use. Whereas the rest do not have significant impact on Intention of use: Perceived Control, Technology Anxiety, and Transaction Cost.

According to the hypothesis presented, results revealed that H1 and H2 are supported. This means that Trialability has significantly positive impact on perceived usefulness (β = 0.684, p <0.01) and perceived ease of use (β = 0.773, p<0.01). In Trialability, providing a trialability information, and make them feel that it's easy to experience the function will increase Perceived usefulness and Perceived Ease of use. However, from standardized regression weight, this indicated that Trialability has better impact on Perceived ease of use than Perceived usefulness. This suggests that for every one standard deviation rise in Trialability, Perceived usefulness increases by 0.684 standard deviation and Perceived ease of use improves by 0.773 standard deviation.

Table 31: Items and Latent in Structural Model.

Latent	Indicators
Trialability	TRIAL1 – I think that I would use APL if I know where I can try
	TRIAL3 – I think I would use if I know it is easy to experiment functions
	TRIAL5 – I think I would use APL if I can try it when necessary
Perceived Usefulness	PU1 - I think APL is the way to get my parcel delivered faster
	PU2 - I think that using APL, I don't need to wait for delivery at home or ask someone else to do it

Latent	Indicators
	PU3 - I think delivery to APL reduce carbon emission
	PU5 - I think that delivery to APL reduce chance parcel get damaged
Perceived Ease of use	PEU1 - I think to get my parcel at the time I'm convenient make it easier
	PEU2 – I think it is easy to use the application to get my parcel
	PEU4 – I think I can understand easily to get parcel from APL
Attitude	ATT1- overall, I think receiving parcel from APL is faster than delivery to home
	ATT2- overall, I think receiving parcel from APL increase convenience to get delivered parcel
	ATT3- overall, I think receiving parcel from APL satisfy me
	ATT4- overall, I think receiving parcel from APL is a good idea
Perceived Control	PC1 – I think that delivery to APL allow me to select APL location that I'm convenient
	PC3 – I think that I can travel to get my delivered parcel
	PC6 – I think that I can control when to go and get my delivered parcel
Technology Anxiety	TA2 – I feel not confident in my ability to use new automated system
	TA4 – I feel apprehensive about using APL
Transaction cost	TC2- I feel that I have to make a significant effort to learn how to use APL
	TC3- I feel that I have to make a significant effort to travel to get parcels at APL
Intention to use	INT2- I would recommend APL to my friends
	INT5- I consider the use of APL to be the first choice for receiving parcel
	INT6- I would choose to try this APL service in the future

Latent	Indicators
	INT7- I think it is possible for me to use APL next time

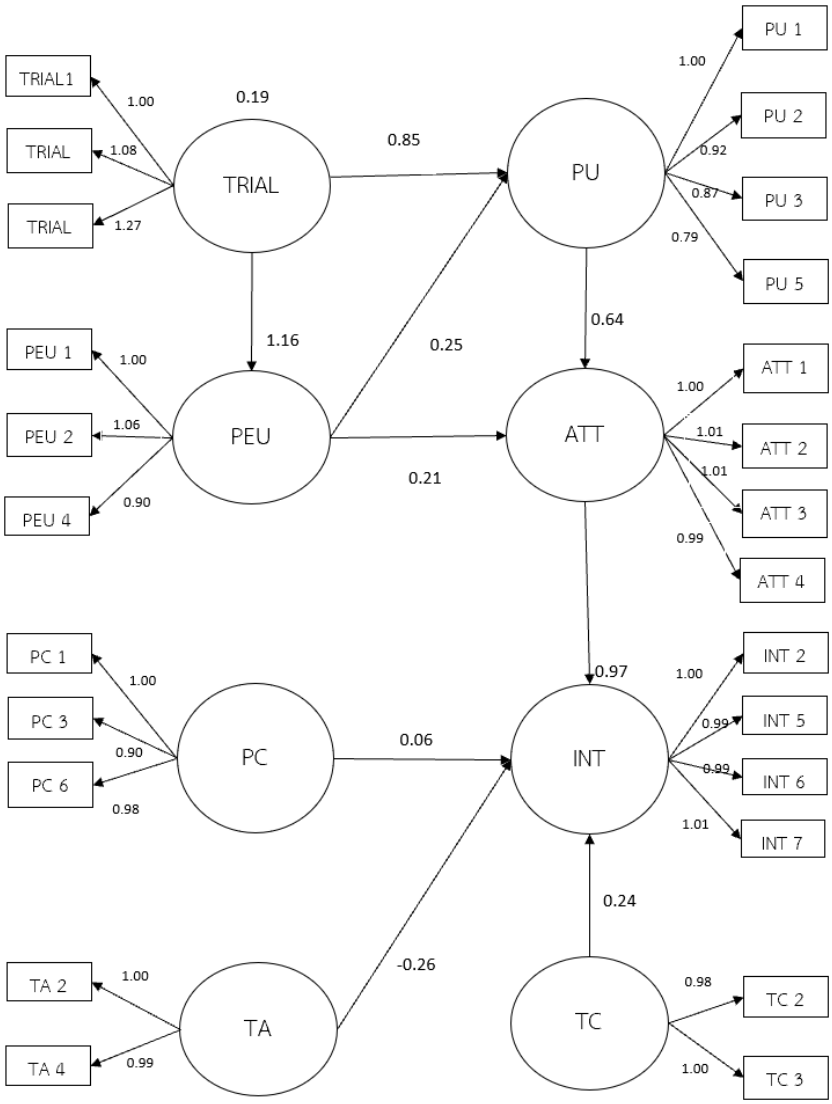

Figure 12: Unstandardized Regression weight

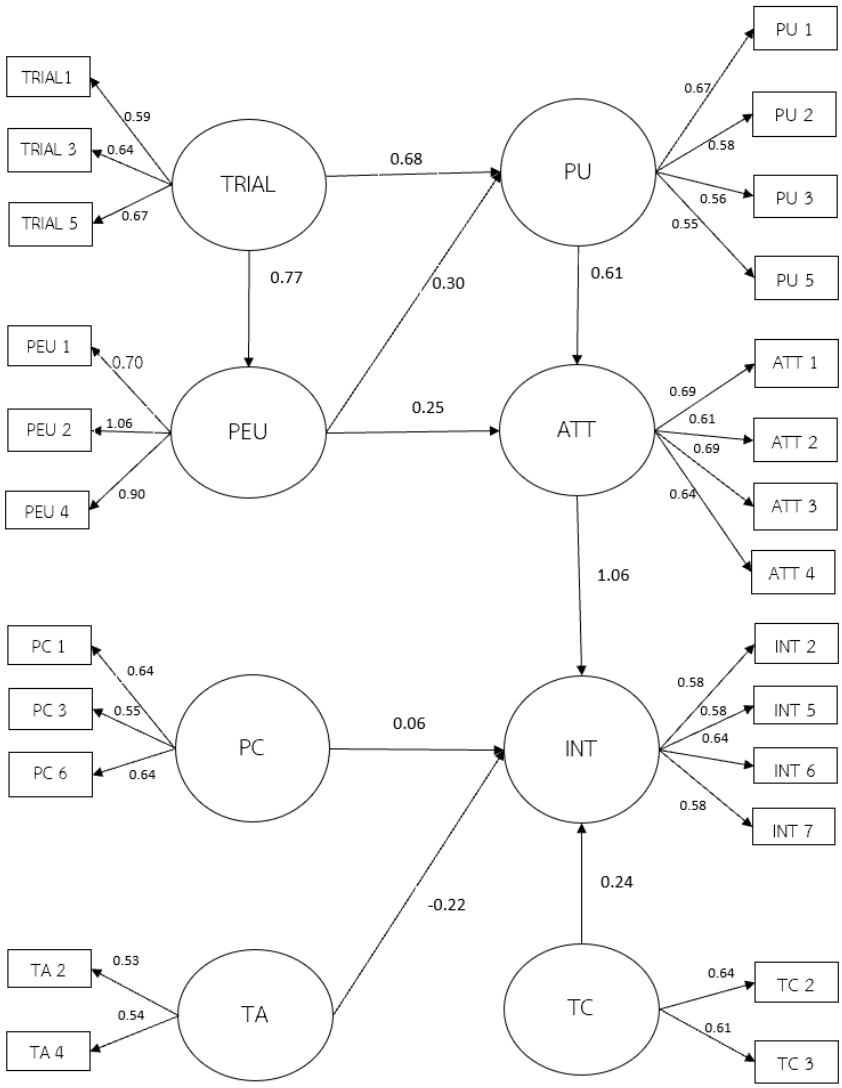

Figure 13: Results of the examined hypotheses in Structural model

Table 32: Examining results of hypothesized causal effect of the constructs

	Path			Estimate		S.E.	P-Value	Hypothesis Results
				Unstandardized Estimate	Standardized Estimate			
H1	TRIAL	→	PEU	1.165	0.773	0.114	***	Supported
H2	TRIAL	→	PU	0.848	0.684	0.125	***	Supported
H3	PEU	→	PU	0.247	0.299	0.074	***	Supported
H4	PEU	→	ATT	0.212	0.246	0.091	0.021	Supported
H5	PU	→	ATT	0.641	0.613	0.119	***	Supported

	Path			Estimate		S.E.	P-Value	Hypothesis Results
				Unstandardized Estimate	Standardized Estimate			
H6	ATT	→	INT	0.968	1.061	0.105	***	Supported
H7	PC	→	INT	0.06	0.057	0.242	0.805	Not supported
H8	TA	→	INT	-0.262	-0.224	0.534	0.624	Not supported
H9	TC	→	INT	0.239	0.242	0.273	0.381	Not supported

Note: TRIAL: Trialability, PEU: Perceived Ease of use, PU, Perceived Usefulness, ATT: Attitude, PC: Perceived Control, TA: Technology Anxiety, TC: Transaction cost, INT: Intention to use. *** p< 0.001, ** p< 0.05

H3 is supported since Perceived ease of use has significantly positive impact on Perceived usefulness (β =0.299, p<0.01). This means Perceived ease of use increases by one standard deviation, it increases Perceived usefulness by 0.299 standard deviation. Moreover, Perceived ease of use has significant positive impact on Attitude (β = 0.246, p<0.05). For Perceived ease of use, it's important to ensure that customers must feel that it is easier to get parcel from APL, application must be user-friendly, and providing how to use is the essential key. Moreover, Perceived usefulness has significant positive impact on Attitude (β = 0.641, p<0.01). This indicates that as Perceived ease of use increases by one standard deviation, Attitude towards APL increases by 0.246 standard deviation and as Perceived usefulness increases by one standard deviation, Attitude towards APL increases by 0.613 standard deviation. Thus, H4 and H5 are supported. For Perceived usefulness, it's important to ensure and pinpoint that customer will not have to wait for delivery like they will have to do with home delivery. In addition, it is good to emphasize the carbon emission reduction from this delivery method and reduce a chance that the goods will be damaged.

In addition, Attitude has significantly positive impact (β =1.061, p <0.01), thus H6 is supported. The result can be interpreted that as Attitude towards APL increases one standard deviation, Intention to use APL increases by 1.061 standard deviation.

This indicates that when customer thinks that receiving parcels from APL is faster than home delivery, satisfying them more, and increase convenience, and this method is a good idea to adopt, it increases intention on recommending APL to friends, considering to use APL as a choice for the next time, choosing to try this new service, and possibly using this for next time delivery option.

H7, H8, and H9 are not supported as Perceived control doesn't significant impact Intention to use (β= 0.06, p =0.805), Technology anxiety doesn't also significant impact Intention to use (β = -0.262, p =0.624). Lastly, Transaction cost doesn't impact significantly on Intention of use (β = 0.239 with p =0.381).

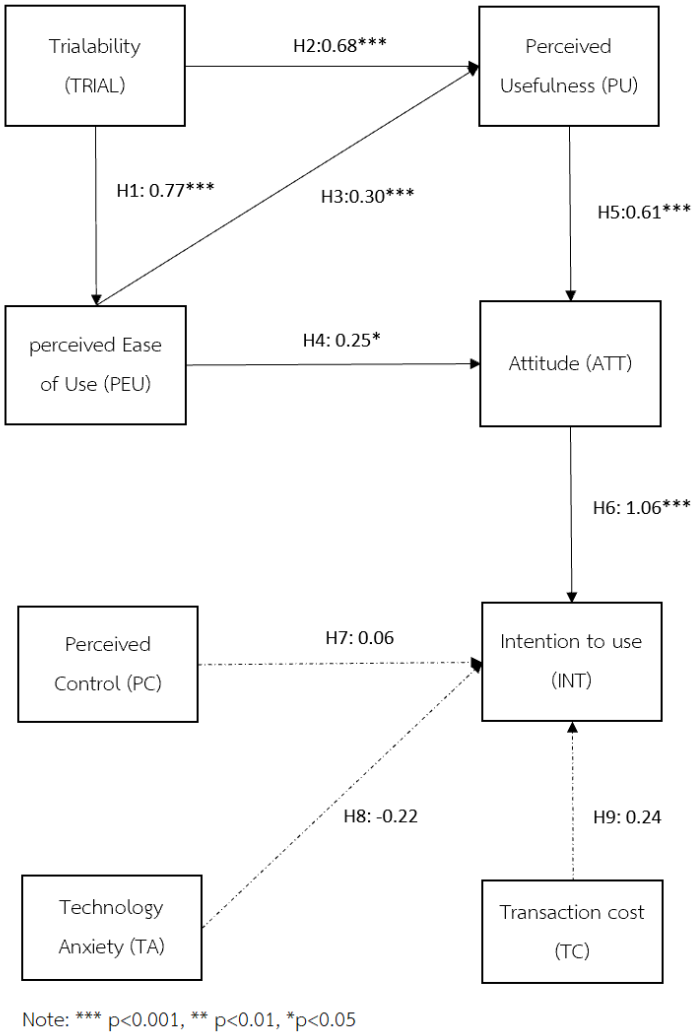

Figure 14: Test result of Structural Model

The squared multiple correlation (R^2) coefficients for latent variables were examined to see how much variance in each latent variable was explained by the mode. The results demonstrated that each latent variable's postulated model explained statistically significant amounts of variance. The R^2 for Perceived usefulness, perceived ease of use, Attitude and Intention to use are 0.87,0.60, 0.69, 0.62 respectively, and As a result, the Attitude error variance is approximately 69% of the Attitude variance, for example. In other words, its two variables, perceived usefulness and perceived ease of use, account for 69% of the variance in Attitude. Overall, the results reveal that all R^2 values match the criteria for the 0.10 cut-off value. (Quaddus & Hofmeyer, 2007).

Result Discussions

The main purpose of the present study is also to investigate what factors influence Intention to use APL. Overall, the study's findings revealed that the data validated the expected structural regression model. For each latent variable, the hypothesized model explained a statistically significant amount of variance. Overall, the model explained a significant amount of variance in statistical outcomes variables (62%). In addition to the overall model fit, the contribution of each latent variable to the model's explanation was considered.

Research findings reported in this study suggest that Attitude towards APL is a direct predictor of intention to use APL, similar to (X. Wang et al., 2018), whereas Trialability, Perceived ease of use and perceived usefulness are indirect influence intention to use via Attitude. This can be interpreted that Trialability, Perceived ease of use, and perceived usefulness are perceived as attractive attributes that contribute to favorable attitude towards APL. This can be concluded that the more the ability to try on this new service, the more they feel that it is useful service and easy to use/understand. However, this finding is contradicted to the previous study from (Y.-H. Lee et al., 2011) that Trialability has negative statistically significant to Perceived Usefulness, but showed the same positive impact on Perceive ease of use. This is also consistent with studies from M. Yang (2007) and Hardgrave, Davis, and Riemenschneider (2003). This implied that if potential customers have more

opportunities to try this APL service, they are more likely to view them as being easier to use and useful. It was contradicting to previous study on Perceived Usefulness, which could be from the fact that the studies were done on different aspect of technology and time where the previous study was done on e-learning system which employees in that study didn't think that this e-learning would help them to develop their capability. In this study, on the other hands, it is mobile application for parcel locker that do not need to measure any performance and require high level of understanding.

Perceived ease of use and Perceived usefulness have significant positive impact on Attitude, which is similar to numerous studies in APL and SST fields (Blut et al., 2016; Y. Chen et al., 2018; Y.-H. Lee et al., 2011; X. Wang, Yuen, Wong, & Teo, 2020; Weijters et al., 2007; Yuen et al., 2019). However, the magnitude of Perceive Usefulness on Attitude is more than that of Perceive Ease of Use in this finding, This might be the reason from the fact that most of respondents do not yet experience application and service, they were aware of it only from the instruction given. This means that the more they feel that this APL service is easy to use/understand and provided benefits over home delivery, the more they tend to satisfy on this new service and feel that it is a better idea to use. One of the important key of Perceived Usefulness is that customer feel that they don't have to wait for the parcel to be delivered at home, while they can go and pick up when they are convenient. This finding is similar to Collier, Moore, Horky, and Moore (2015) in the context that it safe time and customers can have more efficiently experience when they have SST in place. Last, Attitude has a strong influence to Intention to use APL. This is as expected and similar to many researches in TAM in several fields, such as SST and transportation behavioral change (Blut et al., 2016; Curran et al., 2003; Joel et al., 2014; Y.-H. Lee et al., 2011; Lin & Chang, 2011; Lule et al., 2012; Rauniar, Rawski, Yang, & Johnson, 2014; Weijters et al., 2007). This implies that the higher satisfaction potential customers feel toward APL service, the higher degree they tend to use APL, or this will enhance their intention to use APL.

However, contrary to the proposed hypothesis, it was expected that perceived control would be positively significant to Intention to use, the result shows

that perceived control is not significant to Intention to use APL, which is different from a study about intention to use SST, where Perceived control has significant impact on Intention (Demoulin Nathalie & Djelassi, 2016). This means that the beliefs about internal and external constraints on behavior, such as the thought that customers can select their own time to pick up parcel or have a control on location do not related to intention to. However, in other studies, they were all in different context and time in which customers required to have control over their selection such as in retail (supermarket context), Library, and all hotel reservation.

Next, Technology anxiety is not influence Intention to use APL as well, in contrast with a study about intention to use APL from C.-F. Chen et al., (2020) and Blut et al., (2016). In this study, Technology Anxiety consist of the feeling not confident in one's ability to use new automated system and the feeling apprehensive using APL. This would be the perception that this APL technology is not complicated since it is only about using mobile application to received OTP or unlock APL and easily to understand how to interact with Parcel lockers. Moreover, as this is mobile application, users are familiar with this mobile based application, therefore they do not find it difficult to use anymore. The contradiction to another research might be the impact of age which indicated in those studies that most of elderly people will be anxious when they have to use new SST. One reason also might be from the fact that Thai people are familiar with mobile application, as they are heavy internet users (ETDA, 2018).

Lastly, Transaction cost is not significantly influencing Intention to use unlike another study from Yuen et al., (2019) which mentioned that transaction cost significantly impact customer intention to use. The opportunity cost was mentioned to be redelivery, waiting time, and late delivery. From that study, the transaction cost refers to the effort to source information, to learn how to use and the effort to physically travel to collect parcel. The additional cost was asked, however, it was eliminated during model fit process (using Modification index and factor loading). The Transaction cost in this study is similar, it comprises of the effort to learn how to use APL, and the effort to travel to get parcel from APL, however, gave different results. This might be from several reasons: first, most of the customers will use APL when

they are in necessity to use, thus they may have no choice as they cannot wait for home delivery or other alternatives. Secondly, as the location and time are convenient to them as from stated in questionnaire, the sample of APL are located near workplace, shopping mall, in condominium or neighborhood areas. Therefore, there is not much effort from customers to pick up those parcels from APL.Third, from the interview with the customers who had experience using APL, most of them mentioned that there is no likely to have additional cost from their side, as to pick up parcel, it is already on the way home or to their working place. Some mentioned that there is no additional delivery cost to select APL as a delivery mean as the cost is already paid in form of delivery fee.

4.3 Environmental Impacts from Adopting APL

The third objective of this study is to access environmental impact from using APL. As the study leads from identifying what impact probability to use and predict probability to use APL. Next step is to increase the use by understanding what factors influence Intention to use APL. Lastly, it is worth to estimate the change in environmental impacts in different scenario of demand of APL in Thailand context. Estimation of carbon emission was performed using parameters identified from chapter 3. The results are show in the tables below with assumption of same percentage of home delivery failure rate is removed from using APL as the main objective of APL adoption is to reduce home delivery failure rate.

Table 33: Parameter for Estimation for Home delivery

Home delivery		
Parameter		Estimation
total parcels/year	1,460,000,000	
home delivery fail%	10%	146,000,000
total parcels delivered		1,606,000,000
Distance tour/trip	100	

Parameter	Estimation	
parcel/trip	50	
total km for all parcels		100
tour km/parcel	2	
total km for all parcels/year		3,212,000,000
Environment impact		
CO_2 (g/km)	251	
Total CO_2		806,212,000,000

Table 34: Parameter and Estimation for Home delivery and APL adoption

Home delivery + APL		
Parameter		Estimation
total parcels/year	1,460,000,000	
Parcel delivery	10%	146,000,000
Home delivery		1,314,000,000
home delivery fail%	0%	-
total parcels delivered		1,460,000,000
Distance tour/trip	100	
parcel/trip	50	
Parcel locker	10%	5
Home delivery	90%	45

Parameter	Estimation
total km for all parcels	92
tour km/parcel	1.84
total km for all parcels/year	2,686,400,000
Environment impact	
CO_2 (g/km) 251	
	674,286,400,000

The saving from has APL adoption at 10% is 16.36% (131,925,600,000g). Based on the estimation, the reduction in driven vehicle kilometers per parcel reduce from of 2km/parcel to 1.84km per parcel, assuming one APL for one Route. This is similar

Table 35: Saving from comparing 2 delivery methods

Environment impact			
Home Delivery			Home delivery + APL
Vehicle CO_2 (g/km)	251		
Total CO_2		806,212,000,000	674,286,400,000
Saving	131,925,600,000	16.36%	
CO_2 per parcel	502		461.84

to (Hofer et al., 2019) mentioned that the reduction to 1.7km in the city area, but result differently in urban areas which is greater than 2km per parcel. Moreover, the result showed that the average CO_2 per parcel is reduced from 502g/parcel to around 462g/parcel, which is also similar to the finding from Hofter et. al (2019) where the average emissions per parcel is dropped to 432.04 g/percel or 27% reduction in emission per drop or per parcel.

Moreover, Edwards, McKinnon, Cherrett, et al. (2009) reported the saving in carbon emission from 16% to 47% which is higher than the result in this study, while another study showed the decrease by more than 21% of emission (Carotenuto et

al., 2018) which might be from the complexity of scenario such as modes of transports, distance between APL and customer's place, trip chaining, delivery failure rate (McLeod et al., 2006), and dense network of pickup point (Song et al., 2009)

Chapter 5: Conclusions and Recommendations

5.1 Conclusions and Recommendations

The present study provides contribution in three aspects, first, it identified predictors of probability to use APL and examine the marginal effect on each factor. Second, its finding presented factors influencing intention to use APL, aiming to expand and penetrate market. And third, this study provides Carbon Emission reduction analysis from APL adoption to support business and government strategy to encourage the adaptation of this service and support or implement new policy for local air quality.

The first two part of this study, it examines predictors of probability of using APL as well as the factors influencing Intention to use APL. The study's primary goal is to add to the little empirical literature in the APL/self-collection point sector. According to the findings, socio-demographics have a significant impact on the use of APL. To have the right target, women tend to use less APL than men. Age over 45 has the most favorable impact on probability, which encourages the usage of APL. Interesting groups are those who are students and have low level of education, as well as low income. This implies that this APL service is more likely to be adopted by those group of people. While those who have high education and high-income level will have less probability to adopt this APL service. From Behavior perspective, the type of residence positively impacts the probability to use APL is (type of resident: townhouse/commercial building) and condominium/apartment. It also suggested that people who live with parents and their own family (spouse/kids) tend to use APL more than other groups. While shopping experience more than 1 year have negative impact on probability using APL comparing to new user for online shopping. In contrast with Frequency of shopping online, those who do frequent online shopping tend to use APL more than the those who shop less than 2 times/month. It is to conclude that the more frequent they shop online, the more they tend to use APL. From preference perspective, furthermore, the adoption is highly defined by its APL location. The highest locations are condominium and office building, while the shopping mall location would negatively impact the probability to use APL. Discount

price also gives higher probability to use by greater than 30% comparing to normal price. This can be concluded that the locations that are preferred and increase probability to use APL are those location that are near home/living areas or working place but not the shopping mall. The recommendation might be made to business to have the right target market to promote this new service. Internet heaver user with high frequency of shopping online will be targeted to be aware of this APL service. Students and low-income people with age over 45 years old are also target to promote. In addition, the group of potential customer are those who live with spouse and kids or parents as they may not have time to wait or have someone stay home, this will increase the effectiveness of marketing campaign. Furthermore, the locations where the business should pay attention to place APL are in residential areas with clusters such as condominium, where delivery can be consolidated. Office building is also interesting to place this service as referred to the location near working place and easy for potential customer to get parcels. All in all, the channels, promotions, and target market are identified for business to select the right strategy.

Furthermore, the study's foundation is the scarcity of APL expertise and how it influences the probability of use. The outcomes of the study provide companies with information on how to better understand and implement APL. The study's implications here are for the site where the living and working areas are the most impacted (Lachapelle et al., 2018; L. K. d. Oliveira et al., 2017; J. W. J. Weltevreden, 2008). However, this contrasts with European countries such as France, where public transportation is readily accessible and is not the same in this study, implying that Bangkok's public transportation may be inconvenient for potential customers, similar to Brazil (L. K. d. Oliveira et al., 2017). The findings can also be utilized to create new implementing and operating strategies for new parcel locker networks, such as adjusting marketing techniques to attract new clients and have the proper goal.

However, as e-commerce has grown in popularity in recent years, so has the number of home deliveries, which is considered to be a troublesome activity for both customers and carriers. As a result, new delivery methods are being proposed, with APL being one among them. However, this service is still new in Bangkok and is not commonly used. This research also intends to develop a model that can predict

the probability of adopting APL based on socio-demographic, behavioral, and preference data. The findings help to clarify what factors influence probability and how much each factor influences probability, particularly in the proper areas.

Not only to predict the probability but also to target and offer the right things to customers by understanding what influence their intention to use APL. By conceptualizing and validating consumer's adoption behavior of APL, this research also provides insights to the academic researchers and practitioners alike. From academic perspective, this research fills the gaps about the adoptions behaviors and intention to use APL, which is not yet explored in Thailand market. From structural equation analysis, the finding showed that the main impact of intention to use APL is from Attitude towards APL, which impacted by perceived ease of use and perceived usefulness. It can be said that customers must feel that the related function eg. Application, information about using APL and the advantages is clearly communicated. The main driver for both Perceived usefulness and Perceived Control is Trialability which has high impact on both factors. Also, for the first time, it shows that Trialability has high impact to intention to use indirectly. In addition, attitude towards APL is operationalized and empirically validated with respect to consumer intention to use APL, namely, Trialability, Perceived Ease of use, Perceived Usefulness, and Attitude towards APL. Collectively, these variables account for around 62% of the variance in consumer intention to use APL, which is a significant amount in the context of behavioral research (Cohen, Cohen, West, & Aiken, 2013). Other than that, it also shows that Transaction cost is not significant to intention to use. Similar to Perceived control and Technology anxiety which does not impact on Intention to use.

From a managerial perspective, this study sheds light on the management of APL from a commercial standpoint, which can be applied broadly to the management of this innovation. For APL, successful implementation. The finding implies that the presented hypotheses are mutually reinforcing, with each contributing uniquely to the understanding of why customers use APL.

Additionally, this research provides guidance to APL providers on how to increase APL users' intention to use APL. In comparison to conventional home

delivery, APL has a number of advantages that can benefit users. This should be emphasized on Perceived usefulness and Perceived Ease of use. Better service and faster services must be highlighted to customers. The application must be user friendly, to get potential customer feel at ease of using. The business hours of APL must be extended after 18.00 to prepare for the need of after working hours customers. These advantages significantly impact to APL intention to use must be clearly communicated, such as it prevents parcels to get lost or damaged during the delivery at home.

Environmentally friendly service somehow, impacts the intention to use, this can be a marketing point to potential customer as it is identified in the result that customer would perceive this service useful as it helps to reduce carbon emission. Moreover, most importantly, Trialability is the key to encourage those impacts factors indirectly to intention to use. This also indicated that the prioritization should be on Trialability, where customers can have a trial on this service when they are in necessity as well as let them experience this service. Enhancing these factors could position them as a better choice than the other alternatives. In addition, the estimation from comparative analysis of carbon emission. Despite the complementarity of the theories, the findings indicate that they do not have equivalent explanatory power.

The analysis and discussion of the environmental impact, specifically CO2, demonstrated that in certain circumstances, a delivery method based on APL is likely to be superior to an existing delivery method in terms of carbon emission reduction, carrier mileage reduction, and redelivery failure. From the analysis scenario, 16.35% reduction carbon emission can be achieved from 10% of adoption, distance per drop decrease to 1.84 km/parcel and CO_2 per parcel dropped by 8% to 462g/parcel. However, the results are highly sensitive to the parameters assumed in the analysis. Overall, the results suggested that adopting APL reduce carbon emission by average of 16% which is the potential saving from using alternative delivery. This emphasizes that a small change in adoption can benefits to environment. Reduction of Co_2 is globally significant and can be met by increasing the use of APL. This benefit might

be brought to Government attention to encourage this service with subsidy as local air quality is its responsible.

5.2 Limitations of the Study

Despite the contribution of the research work, there is a limitation due to the sample type. The sample's age distribution is not representative of the population, especially when the youngest and oldest age groups are tiny, and the study was conducted in Bangkok and over a small geographic area. Another factor to consider is the possibility that using will not result in actual behavior. (Lemke et al., 2016; Mitrea et al., 2020). As a result, caution should be used when applying the findings to other situations, such as other self-service technology, suburban or rural areas. Those differences may give different results and implication. Thus, it is suggested to expand the research to cover the differences that are mentioned. Third, the study was done with the one who really wanted to participate. Therefore, there might be non-response biased in the parameter estimation (Yuen et al., 2019). Furthermore, similar to (Vakulenko et al., 2018), customer intention to use APL may vary by market, as APL penetration varies. Bangkok was chosen as a representative of a province with increasing use of parcel locker services and a high volume of parcels delivered. Future research can supplement the knowledge gained in this study by conducting research in a variety of market environments. For environmental impact assessment, it is important to consider of several parameters such as customer trips, travel mode, and location of APL. All mentioned above also impact distance and so carbon emission of the trip. Moreover, data collection is theoretical data, it is highly recommended that field data must be collected to represent actual scenario in Thailand context. These limitations offer an opportunity for further research in the field.

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