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Cost Analysis for Last-mile Delivery with Parcel Lockers for a B2C e-Commerce Business: A Case Study of the Company A

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Abstract

This research aims to 1) analyze shipping costs using parcel lockers in a cost-per-order (CPO) model and 2) examine the benefits of locker usage for Thai consumers and businesses in the e-Commerce sector. Quantitative research methods were employed. The analysis utilized average shipping cost data and total online product deliveries within Bangkok from Company A in 2022, focusing on the 5 months with the highest orders. The analysis was conducted using Microsoft Excel for comparative purposes. The findings revealed that: 1) the average CPO for all distribution costs, including home delivery and locker options, indicated that home delivery CPOs were cheaper than those for parcel lockers. Parcel locker usage requires a rental fee, and fixed shipping costs from the warehouse to the locker location. However, locker deliveries boasted a better success rate and fewer failed deliveries. When the shipping cost through lockers is below 20 baht, there is a 10% demand for lockers among total orders. And 2) An additional benefit of locker usage was identified, including cost efficiency, processing time, speed, punctuality, reliability, safety, and service level. Therefore, Company A could consider adopting lockers to meet increasing demand, reduce re-transportation costs due to failed deliveries, and save on fuel expenses, ultimately resulting in cost savings.

Keywords: Cost analysis, Parcel locker, Last-mile delivery, B2C e-Commerce, Self-collection
Type of Article: Research Article

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ผ่านการรับรองคุณภาพจากศูนย์ดัชนีการอ้างอิงวารสารไทย (TCI.) อยู่ในกลุ่ม 2 สาขามนุษยศาสตร์และสังคมศาสตร์

การวิเคราะห์ต้นทุนสำหรับการขนส่งปลายทางด้วยตู้ล็อกเกอร์ในธุรกิจ B2C อีคอมเมิร์ท: กรณีศึกษาบริษัท A

กัญญาภัคณ์ สนธิมโนธรรม*

บทคัดย่อ

การวิจัยนี้มีวัตถุประสงค์เพื่อ 1) ศึกษาการวิเคราะห์ต้นทุนการจัดส่งเมื่อใช้งานตู้เก็บพัสดุในรูปแบบต้นทุนต่อคำสั่งซื้อ (CPO) และ 2) ศึกษาประโยชน์ของการใช้ตู้ล็อกเกอร์สำหรับผู้บริโภคชาวไทยในธุรกิจอีคอมเมิร์ซ ใช้วิธีการวิจัยเชิงปริมาณ ข้อมูลที่นำมาใช้ในการวิเคราะห์คือข้อมูลค่าเฉลี่ยของค่าขนส่งและยอดการจัดส่งสินค้าออนไลน์ภายในกรุงเทพมหานครของบริษัท A ปี พ.ศ. 2565 จำนวน 5 เดือน ที่มีคำสั่งซื้อสูงสุด เครื่องมือวิจัยใช้โปรแกรม Microsoft Excel ในการเปรียบเทียบในแต่ละรูปแบบสถานการณ์ที่กำหนด ผลการวิจัยพบว่า 1) CPO เฉลี่ยของต้นทุนการจัดจำหน่ายทั้งหมด รวมถึงส่วนที่จัดส่งที่บ้านและตัวเลือกการจัดส่งในตู้ล็อกเกอร์ CPO ของการจัดส่งถึงบ้านยังมีราคาถูกกว่าตู้ล็อกเกอร์พัสดุ เนื่องจากตัวเลือกล็อกเกอร์นี้จำเป็นต้องจ่ายค่าเช่าตู้ล็อกเกอร์ และค่าจัดส่งจากคลังสินค้าไปยังที่ตั้งของตู้ล็อกเกอร์มีมูลค่าคงที่ ในขณะที่ร้อยละของอัตราความสำเร็จและการส่งมอบที่ล้มเหลวนั้นดีกว่า และเมื่อต้นทุนค่าจัดส่งผ่านตู้ล็อคเกอร์ต่ำกว่า 20 บาท จะมีความต้องการใช้ตู้ล็อกเกอร์คิดเป็นร้อยละ 10 ของจำนวนคำสั่งซื้อทั้งหมด และ 2) ประโยชน์ด้านอื่น 7 มุมมองของการใช้ตู้ล็อกเกอร์ด้วย ได้แก่ ต้นทุน ระยะเวลาดำเนินการ ความเร็ว ความตรงต่อเวลา ความน่าเชื่อถือ ความปลอดภัย และระดับการบริการ ดังนั้น บริษัท A สามารถพิจารณาการใช้ตู้ล็อกเกอร์จากปริมาณความต้องการที่เพิ่มขึ้นได้เพื่อลดต้นทุนการขนส่งซ้ำเนื่องจากการจัดส่งล้มเหลวและช่วยประหยัดต้นทุนเชื้อเพลิงได้ซึ่งมีผลในการต่อรองราคา

คำสำคัญ: การวิเคราะห์ต้นทุน, ตู้ล็อกเกอร์, การจัดส่งปลายทาง, ธุรกิจอีคอมเมิร์ซแบบ B2C การรับสินค้าด้วยตัวเอง

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1. Introduction

Door-to-door delivery with free shipping is a critical strategy for e-Commerce success in Thailand. Thai customers prioritize free shipping as one of their top three reasons for shopping online (Australian Trade and Investment Commission, 2018). However, this strategy significantly impacts operational costs, particularly transportation costs. Therefore, many companies are encouraging customers to pick up their orders themselves. This strategy offers several benefits: faster fulfillment with less waiting time compared to home delivery, which can help maintain customer loyalty, and it also presents an opportunity to reach out to new customers (Jara et al., 2018). Parcel lockers offer an interesting option for delivering online orders more efficiently and faster (JLL, 2019). These electronic storage units allow customers to collect and return their orders at their convenience, with 24/7 public access (Xiao et al., 2017). While widely familiar in many countries in Europe and the US, their adoption is still growing in Asia (JLL, 2019). This solution can address the pain point of failed delivery due to customers being unavailable at home (McKinnon et al., 2015). Moreover, the benefits of parcel locker consist of efficient choice for customer return, low transportation cost because it can consolidate shipments to drop at one station compared to drop at each customer's house and it can reduce transportation mistakes issue, and lead warehouse operation performance because companies do not need to keep shipments much (Iwan et al., 2016).

This case study demonstrates that parcel lockers can be successfully introduced in the B2C e-Commerce business. Company A's business model involves outsourcing products from various local suppliers. These products are then consolidated in their warehouse before being delivered to customers upon order placement through the company's online platform. According to their 2021 delivery performance data, Company A found that the volume of home delivery in Bangkok is growing. However, the number of failed deliveries due to external factors also rose. The average delivery cost per order is 24 THB, and the current failure rate of 4% exceeds their target of 3%. To address this challenge, they have prioritized initiating a new delivery solution specifically for customers in Bangkok. Company A aims to reduce costs while maintaining a low number of failed deliveries. Parcel lockers appear to be a promising option, potentially to address both objectives. However, implementing this solution presents challenges. As a new approach for the company, it requires investment and implementation efforts. Additionally, limited research on parcel locker usage in the Thai e-Commerce context adds another layer of uncertainty.

This research investigates the cost-effectiveness of implementing parcel lockers compared to traditional home delivery for Company A in Bangkok. The study will analyze delivery cost per order (CPO) under various

scenarios using data from 2021, including online sales volume forecasts for customers who choose home delivery, the current home delivery costs, and the parcel locker rental costs. The analysis will involve defining assumptions and simulating different scenarios to determine the most cost-effective delivery method. Additionally, the research will explore the broader benefits of using parcel lockers.

2. Research objectives

1. To analyze and compare the cost-effectiveness of home delivery versus parcel locker implementation for Company A, focusing on the cost per order (CPO).

2. To investigate the potential benefits of implementing parcel lockers for Thai online shoppers utilizing Company A's services.

3. Literature review

3.1 B2C e-Commerce in fashion in Thailand

Thailand's B2C e-Commerce market is experiencing explosive growth, with a projected annual rate of 20% leading up to 2025 (Business Wire, 2019). This trend reflects a growing preference for mobile and online shopping. The fashion industry is a significant driver of this e-Commerce boom. Online fashion shopping has seen a surge in popularity, with a reported 57% increase in customers from 2013 to 2015 (Thaipublica, 2016). Fashion emerged as the top-selling category in 2019, with a 24% growth in sales volume. The ease of browsing and purchasing clothing online contributes to this dominance. According to the online store in fashion items, the trend in the clothing category is outstanding growth that was influenced by the Internet and technology. Online shopping can generate different fulfillment in consumer responses. It is easy to see the demand and intention to purchase when customers search for fashion items via electronic devices (Blázquez, 2014). However, returns management in online retailing is critically considered because this return policy could impact the competitive advantage (Griffis et al., 2012).

3.2 Last-mile delivery

The definition of last-mile delivery can refer to the final leg in goods and service distribution from the last trader's place or depot to the end consumer's destination (Bopage et al., 2019; Calbeto et al., 2017; Cardenas et al., 2017; Mangiaracina et al., 2019; Sangkhiew & Pornsing, 2018; Wang et al., 2014; Yuen et al., 2018). The significance of last-mile delivery becomes the main challenge of e-Commerce in terms of the total supply chain costs, saving money, and delivering fast to customers (Sangkhiew & Pornsing, 2018). With the demand of e-Commerce, not only online retailers but also shipping companies pay close attention to last-mile delivery; their strategies focus on time, reliability, convenient delivery, and customer experience because of the high competition in this industry (Calbeto et al., 2017). The portion of total shipping cost in e-Commerce represents 53% of last-mile delivery (Anon, 2016); it is expensive and time-consuming due to the rapid online order

numbers, and many businesses compete to provide speed, price, service, and quality in shipping for customer satisfaction (Bopage et al., 2019). Successful last-mile delivery in e-Commerce starts with fleet optimization and delivery tracking solutions based on a robust process and system in warehouse/ DC network design, fulfillment policy, and inventory management (Michel, 2015). The critical success in last-mile delivery is driven by increasing demands on the efficiency and effectiveness of customers, which leads to a firm's performance improvement (Kull et al., 2007). Now, this last-mile operation can be demonstrated in different options, not only home delivery, for instance, drone delivery, which is an ideally innovative solution for decreasing the probability of failed deliveries and customer service level (Mangiaracina et al., 2019).

3.3. Parcel locker

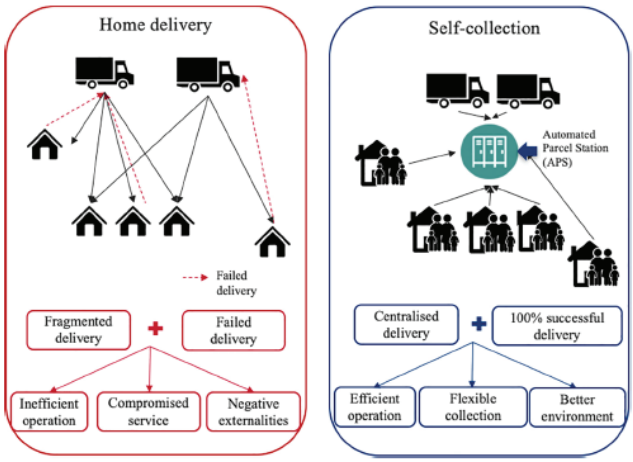


Figure 1 Home delivery compares self-collection (parcel locker) (Wang et al., 2020)

Parcel lockers, a form of technology-based self-service delivery, are considered a solution to improve last-mile delivery challenges as shown in the figure 1 when comparing to the home delivery, it is able to save the transportation costs and enhance the successful delivery rate (Wang et al., 2020). The advantages of well-implemented parcel lockers are multi-faceted. Iwan et al. (2016) identified environmental benefits (reduced carbon emissions and noise pollution), cost benefits (lower redelivery costs, reduced inventory and warehouse operation costs due to less storage needs), and customer convenience benefits (efficient returns, 24/7 access, and convenient locations). These findings align with those of Mangano and Zenezini (2019), who highlight the flexibility parcel lockers offer retailers in managing delivery lead times and inventory. Additionally, parcel lockers can improve customer service by facilitating on-time deliveries and reducing

waiting times. Finally, they offer a more sustainable option for logistics carriers, enabling deliveries with lower emissions in city centers.

Vakulenko et al. (2019) found that implementing parcel lockers for returns can improve the customer experience. When they proceed, the return is decreased, and this option can support the quality and reduce associated costs. This aligns with the findings of Rubio et al. (2019), who suggest that strategically designing a locker network can improve reverse logistics management.

Regarding customer perspectives, parcel locker is an exciting solution for B2C e-Commerce in Polish cities due to their characteristics as eco-friendly, trustworthy providers and location near public transport stations or along the way the customer goes (Lemke et al., 2016). These findings suggest that parcel lockers could also benefit Company A in Bangkok by streamlining the return process for customers, reducing return handling costs, and improving customer satisfaction.

4. Methodology

4.1 Research design

The methodology can start by gathering information from company A, their carrier, and a locker provider, including the sale volume, delivery costs, and locker rental costs. Then, this paper will simulate the scenario based on the locker's condition and analyze the change in total delivery cost and the tradeoff when the locker is implemented. This research will create a tool such as Microsoft Excel to calculate the delivery cost. This concept can be described by this flow in figure 2.

4.2 Population and sample

This section will scope the analysis conditions. Firstly, a carrier will pick up orders at Company A's warehouse and drop them off at the parcel locker the next day. The delivery cost per order to the locker will be set at 24 THB.

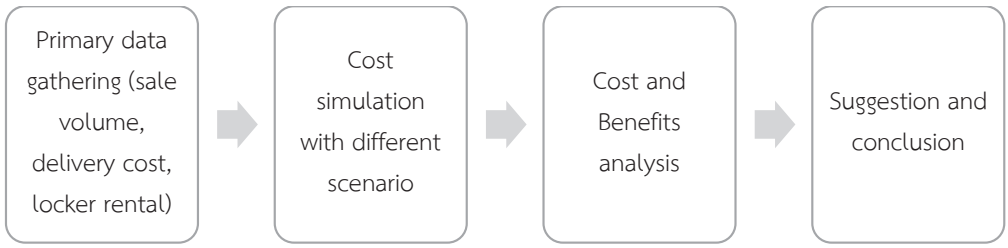


Figure 2 Methodology summary

Table 1 Number of online orders in Bangkok in 2022 (adjusted from Company A, 2021)

January	9,907
February	10,004
March	13,112
April	10,905
May	11,766
June	15,392
July	14,460
August	11,808
September	16,385
October	13,184
November	16,997
December	15,639

Table 2 Average CPO (adjusted from Company A, 2021)

Month	June	July	August	September	October	Grand total
Total delivery cost (THB per month)	947,606	306,000	265,752	273,321	280,620	2,073,299
Total order (order per month)	39,480	12,750	11,073	11,124	11,210	85,637
CPO (THB per order)	24.00	24.00	24.00	24.57	25.03	24.32

Then, each order will be delivered to the locker the next day and will be available for customer pick-up within 5 days. The locker rental cost will be free of charge for the first 3 days. After that, a locker provider will charge 10 THB per order daily. Company A is particularly interested in understanding the total cost per order (CPO) level and assumes that CPO will decrease when customer demand for the locker is higher. According to the locker rental cost condition, company A will assume that customers can be divided into 3 groups (customers pick up within day 3, customers pick up on days 4-5, and no self-collection). However, company A will focus on only customers who come to pick up first because this initial focus aims to assess the potential cost savings associated with a higher successful delivery rate due to fewer failed deliveries using lockers. Furthermore, the overall successful delivery rate is assumed to be 99%, with a 1% failure rate due to unforeseen circumstances.

4.3 Research instrument

This research will be conducted using Microsoft Excel to simulate and compare the CPO of each scenario.

4.4 Data collection

1. Home delivery orders: The forecast volume of Company A's home delivery orders in Bangkok for 2022 is presented in table 1. The average monthly volume is 13,296 orders.

2. Delivery cost: Information on the delivery cost per order for Company A, provided by their current carrier, is included in table 2. This data represents an average cost over 5 months (July-October 2021) and reflects the peak season due to ongoing campaigns. The average delivery cost during this period is approximately 24 THB per order.

3. Successful delivery rate: Company A targets a successful delivery rate (orders delivered to customers) of 97%. Currently, the company achieves a successful rate of 96.47% with a 3.53% failure rate.

4. Failed delivery reasons: The breakdown of uncontrolled factor contributing to failed deliveries is based on reports from company A's carrier. These factors include customer unavailability (not picking up calls, wrong contact number), incorrect addresses, no one at home, career-related issues (loss, damage), and deliveries outside the service area.

4.5 Data analysis

This simulation aims to examine and compare the total cost per order (CPO) using Microsoft Excel when implementing parcel lockers. We will analyze the potential cost savings and delivery performance improvement compared to the current home delivery method. The main scenario involves Company A partnering with a carrier to pick up locker orders from their warehouse and deliver them to designated lockers which will occur the delivery cost. Each sub-scenario with varying locker usage rates will represent a specific percentage of the total order volume using lockers. The number of volumes will identify as 1-10% of the total orders in the sub scenario. Then, this study will analyze different customer self-collection behaviors represented by distinct customer groups (details will be provided in table 3).

These groups may include customers picking up within 3 days, picking up within 5 days, and those not picking up at all. Table 4 will summarize the specific conditions for each scenario, including details on customer pick-up behavior, locker rental costs, and other relevant factors.

Table 3 Percentage of customers of each scenario based on different customer's self-collection

Scenario	Percentage of orders whose customers pick up within the first 3 days	Percentage of orders whose customers pick up on day 4	Percentage of orders whose customers pick up on day 5
A1	70%	15%	15%
A2	70%	20%	10%
B1	50%	25%	25%
B2	50%	30%	20%

Table 4 Conditions details

Details list	Amount	Unit	Remark
Total expected number of orders in 2021	13,296	orders/month	
Percentage of orders that would be picked at locker (i)	1-10	%	The result will be the locker order demand per month
Delivery unit cost	24	THB/orders	
Locker rental cost	10	THB/days	Free 3 days

The total cost will be calculated by combining the delivery cost and the locker rental, and then the CPO will be finalized as below. For variable abbreviations, they can be presented in table 5.

LD = $13{,}296 \times i$ (1)

TDC = $LD \times DUC$ (2)

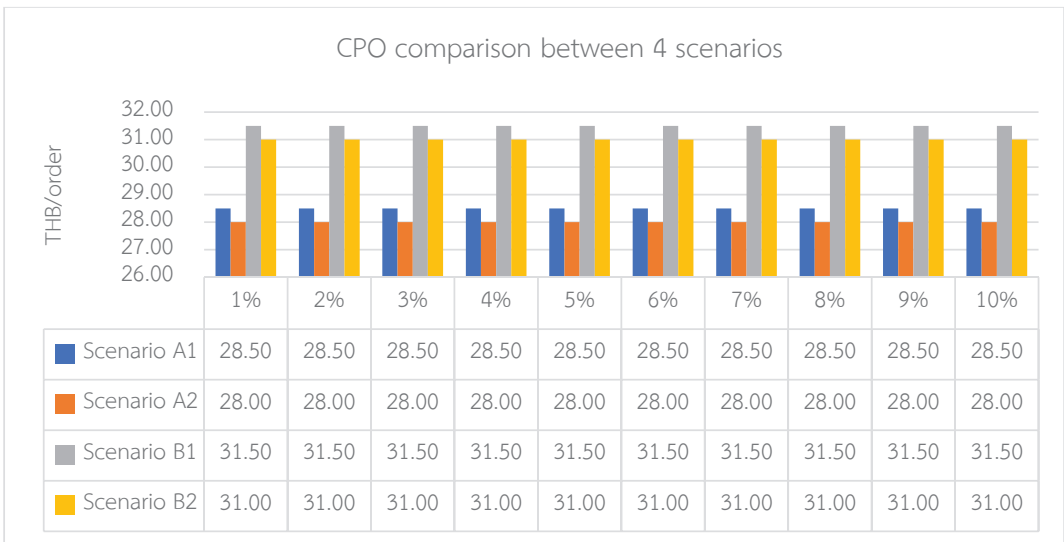
TLC = $LR \times LD \times [(1 \times Y_1) + (2 \times Y_2)]$ (3)

TC = $DC + LC$ (4)

CPO = $\frac{TC}{LD}$ (5)

Table 5 Variable abbreviation

Abbreviation	Meaning	Unit
i = 0.01-1	Percentage of orders that would be picked at locker (i)	%
LD	Locker Demand	Order/month
TDC	Total delivery cost	THB/order
LR	Locker rental cost	THB/order/day
DUC	Delivery unit cost	THB/order
TC	Total cost	THB/month
CPO	Cost per order	THB/order
Y_1	The percentage of customers who pick up in day 4	%
Y_2	The percentage of customers who pick up in day 5	%
TRC	Total Rental cost	THB/month



	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%
Scenario A1	28.50	28.50	28.50	28.50	28.50	28.50	28.50	28.50	28.50	28.50
Scenario A2	28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00
Scenario B1	31.50	31.50	31.50	31.50	31.50	31.50	31.50	31.50	31.50	31.50
Scenario B2	31.00	31.00	31.00	31.00	31.00	31.00	31.00	31.00	31.00	31.00

Figure 3 CPO comparison between 4 scenarios

5. Findings

5.1 Research objective 1: To analyze and compare CPO

The CPO comparison of each scenario is displayed in figure 3. CPO amounts of 4 scenarios rate are flat because DUC is similar value. Interestingly, the result was unfavorable to the initial company A assumption. When the percentage of orders picked up at locker (i) increased, the CPO's result remained the same. Therefore, 4 scenarios can reveal that the i value can change when DUC can be adjusted. For example, if company A can negotiate with this carrier to discount DUC from 24 THB to

23 THB, this will impact on the total CPO of the above scenarios.

To simulate a new result of the average CPO of the total distribution cost, including home delivery unit cost (HDUC) and locker delivery unit cost (LDUC). The purpose of this simulation was to study the average CPO, and when adopting this locker, it can win the average CPO for home delivery only. This simulation adjusted to scenario A2 and showed how much LDUC can reduce with how much of the i value, as shown in table 6. According to these results, if LDUC was higher than 20 THB/order while i values were a small portion, then the average CPO, when adopting this locker idea, was more expensive than a home delivery option. If LDUC was 19 THB/order and below while i values were a more considerable portion than the average CPO when adopted, this locker idea was cheaper than a home delivery option. Therefore, a bigger demand is for customers to select a locker option, and LDUC is 19 THB/order and below. This locker option can win a home delivery option regarding distribution cost. However, this study can support company A in using this idea to negotiate with their carrier for a discount on LDUC.

Table 6 Average CPO of the total distribution cost

DUC (THB per order)		i		
HDUC	**LDUC**	**0%**	**1%**	**10%**
24.00	24.00	24.00	24.04	24.40
24.00	23.00	24.00	24.03	24.30
24.00	22.00	24.00	24.02	24.20
24.00	21.00	24.00	24.01	24.10
24.00	20.00	24.00	24.00	24.00
24.00	19.00	24.00	23.99	23.90
24.00	18.00	24.00	23.98	23.80
24.00	17.00	24.00	23.97	23.70
24.00	16.00	24.00	23.96	23.60

5.2 Research objective 2: The benefits of parcel locker option

This paper found that both home delivery and the parcel locker option offer similar lead times. However, several key factors differentiate between the two options. Parcel lockers provide increased convenience for customers who can pick up their orders at a designated location and flexible time. Additionally, lockers have the potential to improve delivery success rates by reducing failed deliveries due to customer unavailability.

While cost comparisons depend on various factors, lockers might offer cost savings through negotiated delivery costs and reduced failed deliveries. It's important to acknowledge that some customers might still prefer the in-person interaction associated with traditional home delivery. Moreover, the remaining factors can clarify the differences.

1. Cost

While traditional home delivery might appear to be cheaper on the surface, our analysis suggests a more complex cost relationship between home delivery and locker options. Locker rental costs can indeed increase the CPO for lockers.

2. Lead time

While Lachapelle et al. (2018) consider mentioning the specific efficiency gains. Parcel lockers can significantly optimize last-mile delivery. By delivering to a single locker location instead of multiple customer addresses, lockers can reduce the number of stop deliveries needed, optimizing delivery routes. And it will potentially shorten delivery routes, leading to faster delivery times. Additionally, parcel lockers offer significant convenience benefits for customers, especially those living in apartments or condominiums. Customers have the flexibility to pick up their orders at their own time, thanks to 24/7 locker availability (JLL, 2019). Lockers can be strategically placed near public transportation hubs or frequented locations, enhancing accessibility for customers.

3. Speed

While a critical challenge in e-Commerce focuses on speed, especially with same-day services. Posti (2021) suggests same-day or half-day delivery possibilities with lockers.

4. Punctuality

As highlighted by Mangano and Zenezini (2019), parcel lockers can potentially offer greater punctuality compared to home delivery. Unlike home delivery, which relies on carrier schedules and can be subject to delays due to unforeseen circumstances (traffic jams, accidents), lockers empower customers to pick up their orders at their convenience. Parcel lockers typically offer 24/7 access, reducing the risk of missed deliveries due to customer unavailability during traditional delivery windows.

5. Safety

A key advantage of parcel lockers is the potential reduction in physical damage to packages during delivery Logmore (2020). Compared to home delivery where packages go through multiple handoffs, locker deliveries involve fewer handling stages, reducing the chance of mishandling and potential damage. Lockers provide a secure and controlled environment for packages until customer pick-up. This minimizes the risk of damage from external factors that might occur during traditional home deliveries.

6. Reliability

As highlighted by Yuen et al. (2019), it's crucial to prioritize privacy and reliability in parcel locker systems. However, it's important

to consider advancements in locker technology. Modern locker systems incorporate robust security features to address these concerns: Many systems require more than just a password to access lockers. This might involve a combination of PINs, one-time code sent to mobile phones, or verification through dedicated mobile apps. Locker systems often maintain detailed records of access attempts, including timestamps and user identification. These logs can be valuable for reliability purposes and potential retrieval in case of discrepancies.

7. Service level

While the initial analysis indicated a potentially higher CPO for the locker option compared to home delivery, lockers offer a significant advantage in improving successful delivery rates. This is achieved by minimizing failed deliveries due to factors like customer unavailability (not at home, unable to contact). Traditionally, attention shipping is a home delivery service that would have problems in infrastructure in some routing, a trade-off between transportation costs and volumes of orders, and customer order cycle (Kull et al., 2007). This locker approach is particularly suitable for distributing small to medium-sized packages. And it is possible to deliver at non-peak traffic times. They can be adopted to reduce the risk of unsuccessful delivery from customers who are not at home because the locker is located at a residential address (Ranieri et al., 2018).

6. Discussion and Conclusion

The competition of e-Commerce business in the last mile is highlighted to competition. That would be an advantage if a company could deliver to customers faster and at the correct cost. However, home delivery might not always be the final solution to satisfy customers. This challenge can be considered by customers and companies; in particular, the customer's aspect prioritizes delivery speed and punctuality (Mangiaracina et al., 2019), while some companies fail this service at the first delivery, which leads to delayed receiving and rescheduling. The parcel locker is another option to support this last-mile delivery, and this is a new solution in Thailand. According to the scope of this research study, company A is a case study to adopt the parcel locker solution for last-mile delivery. Their objectives are narrowed to cost savings and eliminate the number of failed deliveries. This research focused on the delivery cost analysis regarding CPO and comparing the benefits between home delivery and parcel locker solutions in the Bangkok area on B2C e-Commerce.

The methodology used Microsoft Excel to create general scenarios for cost analysis. Data collection was adjusted from primary data collection in Company A, including their carrier information and locker provider, as well as forecasted sales volume in 2022, delivery costs, and locker rental fees. Under this assumption, Company A allowed customers to collect their parcels within 5 days. When

implementing this locker solution, the delivery performance can be specified as having a 1% failure rate and a 99% success rate. Additionally, they assumed that the total cost per order (CPO) would decrease when customer demand for lockers increased.

These conditions were impacted by the different customer behaviors for self-collection and the different locker rental costs. Therefore, there are 4 comparison scenarios based on the various customer demands on locker and pick-up day.

The results showed that the CPO amounts of the 4 scenarios are flat because the delivery cost is similar in value, and the volume of locker demand was not impacted by CPO as the first assumption. Therefore, it can be concluded that the CPO can change when the delivery cost can be adjusted. Additionally, the cost per order (CPO) of home delivery still outweighs the parcel locker option because there are no additional rental costs, even though the delivery performance did not meet the company's target.

The benefits of parcel locker implementation can be discussed in 7 views: cost, lead time, speed, punctuality, reliability, safety, and service level. These advantages are outstanding in lead time, safety, and especially service level. This locker option can potentially increase the chance of receiving income from customers due to the decrease in failed deliveries. The locker option is convenient for the target audience living in Bangkok, especially those whose surroundings include locker locations such as BTS, MRT, condominiums, etc., and who do not need to adhere to a specific time window for pick-up. Deutsch and Golany (2017) determined that lockers' advantages can reduce city logistics flows and the number of failed deliveries while they are like the scope of the problem solved in the design network. Also, the result agreed to decrease the number of failed deliveries when implementing this locker project (Kedia et al., 2020).

7. Recommendation

7.1 Recommendation for implementing

This study is helpful for online retailers and transportation companies in improving delivery performance to achieve competitiveness and responsiveness. In this case, this study did a further simulation to find an average of CPO in the total distribution cost, including home delivery and locker delivery, when adopting a new locker delivery cost and locker demand. The result explained when an LDUC was higher than 20 THB/order while a locker demand was a small portion. Then, the average CPO, when adopting this locker idea, was more expensive than a home delivery option. If LDUC was 19 THB/order and below 10% of a locker demand, the average CPO was cheaper than a home delivery option when adopting this locker idea. Therefore, it can be concluded that a more significant market is customers selecting a locker option, and LDUC is 19 THB/order and below. However, if the demand for using a locker is higher and

company A can negotiate to reduce LDUC, this locker delivery solution can win.

Moreover, this long-term delivery cost by locker should be cheaper than traditional home delivery because it can reduce the number of re-attempts and costs from failed deliveries.

Furthermore, it can deliver multiple parcels to a single destination instead of making numerous individual drops. This practice helps conserve fuel and reduces the number of vehicles needed, resulting in cost savings (Iwan et al., 2016). From the viewpoint of brand and marketing, a parcel locker is an affordable option to promote and can draw customers' attention through an external design or box screen (Shaun, 2019).

7.2 Future research direction

For future studies, the conditions of this topic may change. For example, the locker rental cost may no longer include free storage time. Such a scenario would necessitate a redesigning of the study's parameters. Additionally, further analysis and study may be required for the return leg, which could involve more detailed considerations.

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