

Exploring the Sustainable Last-Mile Delivery Characteristics on Customer Intention

Go Song Jie¹, Atikah Saadah Selamat^{2*}, Adilah Mohd Din², Azrina Othman², Norhidayah Mohamad¹,
Nur Atika Atan³

¹Fakulti Pengurusan Teknologi dan Teknousahawanan, Universiti Teknikal Malaysia Melaka (UTeM),
Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia

²Sekolah Asasi Teknikal dan Pengajian Diploma, Universiti Teknikal Malaysia Melaka (UTeM), Hang
Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia

³School of Healthcare Management, KPJ Healthcare University, Kota Seriemas, Nilai, Negeri Sembilan,
Malaysia

*Corresponding Author

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ABSTRACT

Nowadays, e-commerce is growing rapidly and more customers expect delivery services that are fast, convenient, and flexible. At the same time, traditional door-to-door delivery may cause problems such as missed deliveries when customers are not at home, which encourages the use of self pick-up options such as pick-up points and parcel lockers. Therefore, the main problem addressed in this study is understanding what characteristics of sustainable last-mile delivery influence customer intention to choose self pick-up delivery methods in the Klang Valley. The purpose of this quantitative study was to use the Theory of Planned Behavior (TPB) as the proposed framework to examine the factors that influence customer intention toward sustainable last-mile delivery. There are five independent variables in this study, like convenient delivery, environmental impact, delivery cost, delivery time, and distance to pick up location, which are associated and customer intention as the dependent variable. A quantitative research design was used to address the research problem and objectives.

The results show that customer intention towards sustainable delivery methods can be influenced by delivery time, distance to pick-up location, delivery convenience, environmental impact and delivery cost. The report also highlights on the customer perceptions on incorporating sustainable approach in delivering the customers' demand, as well as offer practical advice to businesses trying to improve their operational efficiency and competitive advantage.

Keywords: sustainable last-mile delivery, self pick-up, pick-up points, parcel lockers, customer intention, Theory of Planned Behavior (TPB)

INTRODUCTION

The COVID-19 pandemic back into 2020 had accelerated the shift toward e-commerce at an unprecedented rate, changing the way consumers shopping habits. Due to the pandemic, consumers were advised to stay at home to avoid exposure to the virus. This has resulted in consumers becoming more dependent on online shopping platforms like Shopee and Lazada to purchase daily necessities (Cano-Leiva et. al., 2024). The global e-commerce sales show that there was a surge in e-commerce sales from \$3.35 trillion in 2019 and the expected increase to \$8.03 trillion in 2027 (Torres & Cepeda, 2024). At the national level, Malaysia's e-commerce sector exceeded RM1 trillion revenue in 2021, and it will achieve e-commerce sales about RM1.65 trillion in 2025 (The Edge Malaysia, 2022). As a result, the number of parcels requiring delivery to individual customers has increased

significantly. Since consumers rely on online platforms to fulfill their daily needs and wants, the logistics sector was under increasing pressure to meet the customer expectations such as speed, timeliness and efficiency.

The growing number of deliveries has made the “last mile delivery” becomes the global spotlight. Last-mile delivery is defined as the final step in the supply chain process, which transports the consumer goods from a distribution hub, warehouse, or local fulfillment center directly to the end customer’s doorstep (Pourmohammadreza et. al., 2025). Even though this stage is often the shortest in terms of distance, but last-mile delivery is the most complex process and the costliest part of the delivery process. The cost of the last-mile delivery represents approximately 53% of the total shipping cost in the entire supply chain process. Currently, there are various challenges that emerge in last-mile delivery, primarily due to the rising number of vehicles providing door-to-door parcel services. For example, common problems faced by current last-mile delivery include traffic congestion, which can lead to increased fuel consumption and costs, and delivery delays. These problems can contribute to environmental pollution such as transportation emissions while meeting customer satisfaction (Mesquita et. al., 2026). The transportation sector is a major contributor approximately 25% of the global CO₂ emissions as reported by the International Energy Agency (IEA) (Zhu et. al., 2022).

In recent years, the growing public awareness of environmental and social issues has significantly impacted to develop in sustainable businesses, supply chain and logistics. For example, environmental and social issues, including global warming, environmental pollution like air, water and noise, natural material like fossil fuel exhaust, health and safety, and the quality of life. This issue has raised concerns among both the public and the scientific. Since global awareness has increased significantly, individuals and also international organizations act in reducing the environmental problems. For instance, global agreements such as United Nations Sustainable Development Goals have been introduced to guide each country, business and industries move toward more sustainable practices. As a result, the concepts like Corporate Social Responsibility (CSR) and Environmental, Social, and Governance (ESG) principles have become an integral part of modern business strategy (Carroll, 1991; Aydoğmuş et al., 2022). Moreover, these concepts have naturally extended into supply chain management and logistics operations. This has led to introduce of the new concept of “sustainable last-mile delivery” (SLMD) which has also become a focus in the logistics industry, which known as green delivery that delivers the goods to consumers by using a lower environmental impact method (Tran & Gavade, 2025). Initially, sustainable logistics focused on improvements such as increasing transportation fuel efficiency, reducing waste, implementing a green warehouse, and promoting ethical sourcing throughout the supply chain (Carter & Rogers, 2008). The increasing focus on sustainable logistics particularly in the last mile delivery has become important to enhance the efficiency of delivery, minimize the environmental impact, and improve customer expectations in the modern e-commerce era.

As e-commerce continues to become popular, especially in urban areas such as Klang Valley, the pressure on logistics systems has increased because logistics providers need to ensure the deliver efficiently and sustainably. In this situation, sustainable last-mile delivery (SLMD) has emerged as a critical concept that integrates environmental, social, and economic aspects into the logistics and distribution process (Kiba-Janiak et. al., 2024; Moufad et. al., 2025). Rather than only focusing on low-emission vehicles, SLMD encompasses a broad range of strategies to reduce negative impacts on the environment while maintaining a high service quality. There are several sustainable last-mile delivery strategies including drone, pick-up point, electronic vehicles (EVs), and automatic locker. This research will focus on one type of sustainable last-mile delivery which is the pick-up point method. It is the most commonly used approach in Malaysia compared to other sustainable last-mile delivery methods like electric vehicles and drones. This method allows customers to collect parcels from specific locations such as smart lockers, retail stores, or micro-hubs. As a result, pick-up methods can help in reducing the environmental impact by consolidating deliveries, which reduces the vehicle usage (Janinhoff et. al., 2024). From a social perspective, the pick-up method can minimize noise, congestion and maximize safety in the residential areas. It also reduces workload and stress on delivery workers, while improving their working conditions and safety in last-mile delivery (Pourmohammadreza et. al., 2025). From the economic site, the pick-up point approach helps logistics companies plan a better route and avoid failed deliveries. It can help the logistics provider to save time, fuel and labor costs, and supports long-term success by increasing profits, keeping customer satisfaction, and loyalty. Thus, these environmental, social, and economic aspects make the pick-up

point as a one effective method of a sustainable last-mile delivery system. The rapid growth of e-commerce and the evolving delivery expectations of consumers highlight the importance of sustainable last-mile delivery practices. With the increased reliance on online shopping, logistics providers and e-commerce platforms must adapt to more sustainable approaches to meet environmental goals and customer expectations.

Consumer behaviour has changed significantly in recent years due to the growth of e-commerce. Online shopping has become the main choice among worldwide consumers and is replacing the previous dominance of physical store purchases (Liu, 2024). As e-commerce continues to expand, people are more relying on it in order to fulfill their daily needs and wants. This shift has brought convenience for the consumer. At the same time, it has led to consumers increasing their expectations for last-mile delivery, including faster services such as same or next-day delivery. Consequently, the last-mile delivery systems are facing higher challenges and pressures. The rise in online shopping orders has led to more frequent deliveries and forcing logistics providers to invest in the expansion of delivery vehicles like vans and trucks to maintain customer satisfaction (Raj & Thandayudhapani, 2024). According to the 2020's World Economic Forum claimed that without an effective solution, the number of delivery vehicles in the world's 100 largest cities is projected to grow by 36% by 2030 and causing an increase of 32% of carbon emissions and a 21% rise in traffic congestion (Hillyer, 2020). It is clearly indicated that the conventional last-mile delivery heavily contributes to global pollution. The question is, how can the conventional last-mile delivery vehicle release more than pollution globally. According to Fedge (2025) there are some common last-mile delivery problems leading to an increase in pollution to the environment. The conventional last-mile delivery not only incurs high costs but also contributes significantly to global pollution. The conventional last-mile delivery accounts for more than 53% of total transportation costs, primarily due to various reasons such as high fuel consumption, hard in finding customer addresses, manpower cost and first-time delivery failures (Guerra-Regalado & Guevara, 2025). It indirectly indicates that the conventional last-mile delivery will consume a significant amount of fuel and higher carbon emissions, as couriers must drive delivery vehicles through complex routes in search of customers' homes. When it is in urban areas like Klang Valley, the couriers might face some problems such as traffic congestion, multiple delivery stops and risk of failed first attempts. As a result, it will cause more carbon emissions due to an extra fuel consumption, especially when the engine is still operating while waiting for traffic congestion and re-attempting delivery. The conventional last-mile delivery could contribute approximately 25 million tons of carbon emissions per year by 2030, which would be harmful to the environment (Hu et. al., 2024). According to Janinhoff et. al., (2024), the Out of Home Delivery Survey shows that consumers have a strong preference for home address delivery. This indicates that most of consumer still prefer the convenience of having their parcel delivered directly to their homes (Kashif et. al., 2023). While out-of-home delivery such as service point, parcel locker, retail store, work address and to a point on commuting route is important to grow, establish and increase the efficiency of the logistics industry. However, the data indirectly show that the customer's intention to adopt more sustainable delivery methods still remains lower.

According to the Sarkar (2023) claims that the last-mile delivery transportation such as vans, trucks, and motorcycles relies on fossil fuels like petrol and diesel which contribute hugely to climate change. United Nation emphasized that over 75% of the global greenhouse gases and nearly 90% of carbon dioxide emissions come from fossil fuels. Since many logistics service providers keep adopting more and more vehicles to meet the customer's expectations, carbon emissions from the transportation sector account for about 25% of the total global emissions and lead to road transportation becoming the largest source that contributes to carbon emissions due to the consumption of gasoline and diesel in delivery vehicles (United Nations Environment Programme Report, 2021). As a result, greenhouse gases can have a lot of negative effects on the planet, the environment, human health and ecosystems. One of the negative effects is global temperatures are rising year by year. According to 2021 IPCC report, each decade since the 1980s has been warmer than before. When the global temperature increases, the risk of wildfires also will increase, which will damage forests and human homes. At the same time, it will release harmful smoke into the air causing a serious health risk to humans. Moreover, the rising global temperatures accelerate the melting of glaciers and result in rising sea levels. Back in 2018, UNESCO had released information that shocked the world where 78% to 97% of the glaciers in the tropical Andes will disappear by 2100 due to the rise in high elevation surface air temperature (Launch of an Atlas on the Retreat of Andean Glaciers and the Reduction, 2023). The rising sea level could increase the risk of flooding,

which can cause to physical injury, death, exposure to chemical hazards and diseases spread through the contaminated water.

While sustainable last-mile delivery has been explored in global logistics research, there is a lack of contextual studies within Malaysia. Most of the existing studies about the sustainable last-mile delivery focus on the mobile application or the study conducted in western or developing countries such as Germany, China and France. In addition, it remains a significant knowledge gap about the term sustainable and the adoption of sustainable last mile delivery options in Malaysia. The usage of sustainable last-mile delivery methods like the pick-up point method is still limited in Malaysia (Darren et. al., 2023). This is due to the barriers like limited availability, lack of accessibility and low public awareness regarding the concept of sustainable in delivery service and the negative impact of using commercial last-mile delivery on the environment, social and economic. Therefore, these environmental impacts highlight the urgent need to transition from conventional last-mile delivery to a new concept, sustainable last-mile delivery to reduce the dependence on fossil fuel and greenhouse gases while mitigating the long-term negative consequences to society and the environment.

LITERATURE REVIEW

The examination of the past research literature provides the comprehension on the sustainable last-mile delivery and customer intentions, by exploring the concepts of last-mile delivery with the perspective of Theory of Planned Behavior (TPB). The review then delves into various studies and theoretical frameworks that examine the impact of these sustainable last-mile delivery elements such as convenient delivery, environmental impact, delivery cost, delivery time and distance to pick up location on the customer intentions.

Last-mile Delivery

Last-mile delivery refers to as the final step in the supply chain process where the customer is transported from a last transit point such as a distribution center or transportation hub to the end customer or final drop point (Mangano et. al., 2021). It also emphasizes on to the final step in the delivery process to the customer has become very important to both businesses and consumers (Chuyen et. al., 2025). The main goal of convention last-mile delivery is to deliver customer goods in a shorter time, gain a high profit, and also provide a high service level to ensure customer satisfaction. While the last mile plays a key role in maintaining customer satisfaction, it is also inherently complex and often problematic. It is because the last-mile delivery is considered as the most costly, inefficient, and most polluting part in the supply chain process. This last-mile delivery is considered the most complex and expensive part in the entire supply chain process, especially in the delivery process due to the traffic, routing and customer specific requirements, with its cost reaching up to half of the total logistics cost (Mangiaracina et. al., 2019). Urban areas are particularly affected by some issues like traffic congestion, air and noise pollution, and frequent delivery failures which affect the environmental quality, logistics companies and customer satisfaction. Therefore, understanding the challenges facing the last-mile delivery is important to address these issues and find better solutions.

Sustainable Last-mile Delivery

The term sustainability becomes important, and it has spread across all industries including last-mile delivery sector. According to Klein and Popp (2022), sustainability is defined as meeting the needs of the present without compromising the interests of future generations. Nowadays, all companies should focus on the ‘triple bottom line’ including social, environmental and economic aspects to minimize the harmful activities that are especially generated by transportation and minimize harm to quality of life and the environment. As customer demand for e-commerce increases, it leads to logistics service providers should increase the number of freight transportation to fulfil the customer demand. As a result, it is may contributing to environmental issues such as greenhouse gas emissions, climate change and pollution (Biancolin & Rotaris, 2024).

This sustainable last-mile delivery emphasized on the environmental aspect by using a green transportation method to move goods from a merchant, seller, warehouse and distribution to a customer while minimizing the harm to the environment (Lauenstein & Schank, 2022). Ignat and Chankov (2020) had explored the consumer

behavior in relation to being sustainable in regards to economic, environmental and social sustainability factors in last-mile delivery, where they highlighted each aspects impact on the last-mile delivery. For economic sustainability, last mile delivery is affected by delivery cost, speed and choice, while environmental sustainability affects the last mile delivery in terms of the vehicle's emissions, voice production and the waste derived from the packaging.

In addition, most people found that sustainable practices are not only an ethical choice, but also key to business success and gaining consumer support (Zhang, 2024). Research has shown that providing e-commerce customers with information on the environmental and social impacts of different delivery methods can influence their choice to choose an alternative delivery method (Salgado et. al., 2026). An individual with pro-environmental attitudes and knowledge will make them more likely to choose sustainable last-mile delivery methods (Ignat & Chankov, 2020).

Delivery Methods

Since online shopping has grown rapidly, different methods of last-mile delivery have been used to increase efficiency, reduce costs and meet customer needs and wants. Among various methods, the most frequently used in the last-mile delivery is the home delivery. It is known as the traditional and conventional delivery method that is the most common method used in delivery industry. It delivers the customer's parcel directly to their home. This method is known to be very convenient as customers can receive their parcel at their doorstep. However, home delivery also carries this costly and poses problems such as not being able to deliver when no one is home. It also leads to more traffic and environmental pollution especially because the delivery trucks travel longer distances (Mangiaracina et. el., 2019).

To address these challenges, one of the alternative solutions is Collection Point or Pick-up Point approach have been introduced. This method has also been referred to as pick-up points or parcel lockers and have become an increasingly popular alternative delivery method (Klein & Popp, 2022). This method involves delivering packages to a designated secure location, such as a retail store, post office or parcel locker, where customers can retrieve their items at their convenience place and time. However, there are some differences between the pick-up point and the parcel locker. The pick-up point in which, also known as a manned collection point usually operates on weekdays during the regular business working hours. Whereas, compared to the parcel locker, the parcel locker is accessible all the time, 24 hours, 7 days a week and allows customers to collect their parcel at any time based on the conveniences, since it is an unmanned collection point. The collection point method has the potential to address the inefficiencies of the home delivery issue and also provide some benefits such as flexibility, low carbon emission and typically lower shipping costs (Yuen et. al., 2018). Similarly, click-and-collect (C&C), in which customers order online and then pick up their goods directly at a physical store.

Delivery Convenience

Convenience is one of the crucial characteristics that influence customer preferences when choosing a delivery method. Especially in terms of the delivery speed, convenience plays an important role in shaping the customer experience, online shopping behavior and also choice of delivery method. In today's fast-paced environment, consumers increasingly value short and precise delivery windows and quick turnaround times, which greatly enhances their perception of convenience. Ignat and Chankov (2020) highlighted that customers wish to get their goods or parcel anytime and anywhere. With that focus as well as the sustainable last-mile delivery, pick-up points, or collection points, it has emerged as a convenient unattended delivery solution (Klein & Popp, 2022). Pick-up points offer consumers a flexible way to collect their parcels at designated locations. This pick-up point can be attended, such as micro hubs, retail counters or post offices, or unattended, such as parcel lockers. The parcels are usually kept and stored at collection points for a few days 26 until the consumer goes to the collection point to pick up their parcel. Usually, the collection points may be located closer or farther away from the customer's location, but the collection points are generally located in a strategic location that is easy for the consumer (Bruno et. al., 2025). Locating a collection point within a 10-minute walk of a busy area, such as a home, office or shopping center, can make it easier for consumers to reach. Despite that, research shows that the pick-up points are not always perceived as the most convenient method, since customer expectations of

convenience include fast delivery and accurate delivery windows. At the same time, consumers also prefer saving time and avoiding travelling to physical stores (Zielke & Komor, 2025). Compared to the pick-up point, home delivery is perceived as more convenient, since collecting parcels from pick-up stations is seen as an additional time cost. At the same time, consumers also need to spend extra time traveling to collection points, parcel lockers or Click & Collect (C&C) locations.

Klein and Popp (2022) believed that the main reason people choose parcel lockers is the flexibility to pick up parcels at their convenience, rather than saving time or getting faster deliveries. For C&C and collection point services, customers require planning a schedule or choosing a collection time to pick up their parcel within the opening.

H1: There is a significant positive relationship between delivery convenience of sustainable last-mile delivery and customer intention.

Environmental impact

Nowadays, CO₂ emissions have been chosen as a key factor in environmental terms, as there is increasing pressure to reduce emissions from logistics activities (Cheng et. al., 2024). The study suggests that sustainability and environmental impacts are becoming one of the important factors that influence consumers' choice to choosing delivery methods. According to Klein and Popp (2022), they found that while delivery speed and cost are still more important, environmental information can also influence consumer decisions to choose an alternative last-mile delivery method. Home delivery is considered the least sustainable option compared to pick-up points and click-and-collect (C&C). Yuen et. al., (2018) claimed that people with strong environmental awareness may be more likely to choose self-collection, since they will consider the self-collection method as an eco-friendlier option compared to home delivery. The pick-up point and click-and-collect help reduce emissions and support a more sustainable last-mile delivery in the future.

H2: There is a significant positive relationship between the environmental impact of sustainable last-mile delivery and customer intention.

Delivery cost

The cost of delivery is a key factor in consumers' choice of delivery method (Klein & Popp, 2022). Nowadays, many consumers expect free delivery, and there have been many studies showings that most of consumers are often unwilling to pay extra for delivery services. According to Joerss et. al. (2016), around 50% of consumers are willing to change their last-mile delivery behavior to self-collection services if the door-to-door delivery costs at least \$3 more than the self-collection option. Additionally, last mile delivery is the most expensive part in the supply chain process (Jagoda et. al., 2023). Therefore, delivery cost becomes the top priority for customers, often ranked as the most important factor when choosing a delivery method (Ignat & Chankov, 2020). However, consumers are generally willing to accept longer delivery times if they can reduce costs, which can also help retailers build more efficient logistics systems (Tian et. al., 2025). Typically, the shorter delivery time, like same-day delivery, may result in a higher delivery cost. So, the pick-up points options have become a delivery alternative method that is more attractive to consumers since the costs of pick up points are lower than other delivery methods like home delivery.

H3: There is a significant positive relationship between the cost of sustainable last-mile delivery and customer intention.

Delivery time

In the current era, customers are increasing their expectations toward faster deliveries and shorter delivery times when they place an order (Ignat & Chankov, 2020; Amaya et. al., 2024). Nowadays, there are different delivery options provided for customers like getting their package on a specific day or during a certain time, such as in the morning, afternoon or evening. For example, the sustainable last-mile delivery like pick-up points offers

consumers a flexible way to collect their parcels at designated locations. This pick-up point can be attended, such as micro hubs, retail counters or post offices, or unattended, such as parcel lockers. By comparing the pick-up point and parcel locker, the advantage of the parcel lockers is that they operate 24 hours a day, 7 days a week (24/7), allowing customers to pick up at any time, unlike the collection points which have limited opening hours and dates. Besides that, the number of cases of first-time delivery failures always increases due to some factors like customers not being available at home, weather issues, traffic congestion and inadequate number of delivery drivers. It was leading to an increase in delivery time, costs and carbon emission by redelivery again of the parcel from the warehouse to the end customer (Klein & Popp, 2022). Therefore, self-collection can help to improve the delivery success rate (Yuen et. al., 2018).

H4: There is a significant positive relationship between delivery time of sustainable last-mile delivery and customer intention.

Distance to pick-up location

The distance or accessibility of pick-up points is a practical consideration for customers. Yuen et. al., (2018) mentioned that one of the factors such as the location of self-collection points can encourage a consumer to move toward a greener delivery method, which is by having more pick-up points can be beneficial for customers as it shortens their travel distance to pick up their parcel. Klein & Popp (2022) claimed that consumers usually use collection points when they are going to work or performing their daily tasks, which helps to minimize the negative impact on the environment. Compared to home delivery, the collection points are usually cheaper, with zero failed deliveries, and customers can pick up their parcels at a time that is convenient for them (Hovi & Bo, 2024). For example, when the location between a carrier and a customer is very far. So, customers may choose alternative delivery options like the pick-up method. They can pick up a parcel at pick-up points like a post office, parcel locker, and a convenience store like 7-11 that is nearby to them or they visit regularly. In this way, consumers can collect their parcels while shopping without making a separate trip. Therefore, it is necessary to expand the number of collection points to reduce the travel distance between a consumer and pick-up points (Kedia et. al., 2020).

H5: There is a significant positive relationship between distance to the pick-up location of sustainable last mile delivery and customer intention.

METHOD

This research uses quantitative research design specifically exploratory research. Approximately 430 questionnaires are distributed to respondents which specifically focuses on e-commerce customers who use, experience, and are interested in the last-mile delivery service in the Klang Valley region, West Coast of Malaysia. Klang Valley was selected as the research location because it includes the major urban centers such as Kuala Lumpur, Selangor, and Putrajaya. Klang Valley is recognized as one of the most highly populated, estimated to be 8.8 million people and rapidly developing regions in Malaysia. Klang Valley also serves as a hub for e-commerce and logistics activities in Malaysia. The research closely examined the demographic variables of e-commerce users and the sustainable last-mile delivery features in order to examine the potential usage of that impact the intention to use the last-mile delivery service. The primary instrument for data collection in this research is closed-ended questionnaire. The study adopts non-probability sampling, specifically purposive sampling, where the respondents are selected based on specific characteristics and the purpose of the study. The purpose of using purposive sampling is to ensure that the data collected is relevant and directly aligns with the research objective, which focuses on sustainable last-mile delivery and influencing customer intention.

RESULTS AND DISCUSSION

Descriptive analysis

Data were collected from 426 respondents that actively involved in e-commerce activities and intention to use sustainable delivery method, such as last-mile delivery approach. Age, gender, number of packages received per

month and preferred e-commerce platform are all personal information considered in this study.

The age range of the respondents is between 25 and 60 years old. 33.6% of the respondents are in the range of age 26-35 years old, while the respondents in their 60 years and above only the 7% of the respondents. The largest group is the ones in the aged between 26-35 years at 33.6%, followed by those aged below 25 years at 29.8%. These groups constitute the majority and are likely to represent the customers that majorly involved in e-commerce activities that play a significant role in adopting and have intentions in sustainable delivery method, specifically last-mile delivery. The research constitutes fairly equal numbers of respondents in terms of the gender, as 50.7% are male while the remaining 49.3% are female respondents. Different gender may provide different perceptions in sustainable delivery methods approach.

As for number of packages received per month, the highest number of packages received per month is the range between 6-10 packages which is at 31.5%, followed by less than 5 packages per month at 23%. The remaining portion of respondents is distributed across the range of 11-15 packages at 21.4%, 16-20 packages at 16%, and more than 21 packages at 8.1%. The results indicate that most respondents receive a moderate number of packages per month, reflecting regular engagement in e-commerce activities. Most of respondents, at 40.1% of respondents are preferred Shopee as their preferred e-commerce platform, while Lazada at 15.3% and the least preferred platform chosen by respondents is Amazon at 2.3%. The other platforms such as Temu, Taobao, TikTok Shop, Mudah.my and Zalora recorded very little preferences.

Correlation analysis

The Pearson Correlation test examined the relationship between independent (Delivery Convenience, Environmental Impact, Delivery Cost, Delivery Time, Distance to Pick-up Locations) and dependent variable (Customer Intention). The outcome of the correlations is summarized in Table 1. As shown in Table 1, all variables are significantly linked to the characteristics of sustainable last-mile delivery do effects on the customer intention. As a result, it indicated that, Delivery Time has the highest correlation value with 0.819 which is significant at <0.01 level (1 tailed). Delivery Cost, on the other hand, has the lowest correlation value of 0.750, which is significant at the <0.01 level.

Table 1: Pearson Correlations

		Delivery Convenience	Environmental Impact	Delivery Cost	Delivery Time	Distance to Pick-up Location	Customer Intention
Delivery Convenience	Pearson Correlation	1	.757**	.802**	.804**	.768**	.773**
	Sig. (1-tailed)		.000	.000	.000	.000	.000
Environmental Impact	Pearson Correlation	.757**	1	.725**	.739**	.752**	.754**
	Sig. (1-tailed)	.000		.000	.000	.000	.000
Delivery Cost	Pearson Correlation	.802**	.725**	1	.749**	.807**	.750**
	Sig. (1-tailed)	.000	.000		.000	.000	.000
Delivery Time	Pearson Correlation	.804**	.739**	.749**	1	.768**	.819**
	Sig. (1-tailed)	.000	.000	.000		.000	.000
Distance to Pick-up Location	Pearson Correlation	.768**	.752**	.807**	.768**	1	.797**
	Sig. (1-tailed)	.000	.000	.000	.000		.000
Customer Intention	Pearson Correlation	.773**	.754**	.750**	.819**	.797**	1
	Sig. (1-tailed)	.000	.000	.000	.000	.000	

Multiple Regression analysis

Multiple regression analysis was utilized in this study to investigate at the impacts of independent variables (Delivery Convenience, Environmental Impact, Delivery Cost, Delivery Time, Distance to Pick-up Locations) and dependent variable (Customer Intention). The results of multiple regression analysis for the customer intention are summarised in Table 2.

Table 2: Model Summary

Model	R	R ²	Adjusted R ²	Std. Error of the Estimate
1	.871 ^a	.759	.757	0.33317

The R-square value was .759, indicating that the five independent variables can explain 75.9 percent of the variance in the customer intention. Other variables not examined in the study influenced the remaining 24.1 percent. The Adjusted R Square, therefore, considers model complexity and results in a very high explanatory power of 0.757.

Empirical Results

Table 3 has shown that each of the independent variable contributes differently in predicting customer intention. The higher of the standardized beta value, the greatest influence on customer intention. Among all variables, Delivery Time is the strongest predictor of customer intention with a highest standardized beta value of 0.369, and p-value of < 0.001. This indicates that delivery time is the most significant characteristics of sustainable last-mile delivery that influence on customer intention compared to the other independent variables.

While less noticeable and not statistically significant of p value of 0.200, Delivery Cost also has a positive impact on the warehouse performance with a Beta value of 0.060, where Delivery Convenience's Beta value at 0.103, indicating that both coefficients still have influence with small or less relation to the customer intention to last-mile delivery usage, but not statistical significance accepted.

The sign of the regression standardized estimate (Beta) represents the positive or negative impact of the predictors on the dependent variable. Therefore, it can be stated that all determinants have positive effect on the customer intention with the knowledge on characteristics of sustainable delivery methods.

Table 3: Coefficients

Characteristics of Sustainable Delivery Methods on Customer Intention	= 0.017 + 0.103 (DC ¹) + 0.164 (EI) + 0.064 (DC ²) + 0.366 (DT) + 0.303 (DPL)
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Model	Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	Sig.
1	Constant	.017	.125	—	.138
	Delivery Convenience	.103	.049	.103	2.127
	Environmental Impact	.164	.043	.158	3.839
	Delivery Cost	.064	.050	.060	1.284
	Delivery Time	.366	.045	.369	8.198
	Distance to Pick-up Location	.303	.053	.267	5.725

With reference to Table 3, the regression equation is as follows:

Discussion and Research Implications

This study had interpreted and contextualized the model to identify and suggest a few factors, that may influence

the intention of e-commerce customers. The noteworthy theoretical contribution explains and defines the relationship between the characteristics of sustainable delivery methods and the customer intention. The research has congruent similarity with the study done in Vietnam on pick-up point and smart locker services by Nguyen et. al. (2024), where the research also aids academic scholars and practitioners by conceptualizing and validating the influence of sustainable delivery methods characteristics on customer intention among e-commerce customers. The study indicates that the convenience has a positive relationship that affect the customer intention to use the self-pick-up service in last mile delivery. The authors highlighted that convenient play an important factor in encouraging users to adopt pick-up point services, especially in urban areas with busy lifestyles. It is because, pick-up point services can help to reduce effort required for parcel collection and provides greater flexibility compared to home delivery. Similarly, a study carried out in Thailand done by Tsai and Tiwasing (2021) focusing in customer intention in Southeast Asian urban contexts, where they also found out that consumers prefer delivery options that allow them to collect parcels at their preferred time and location, which enhances perceived convenience and increases intention to use smart lockers. Another study carried out by Klein and Popp (2022) based in Germany indicated that delivery methods that are easy to use and fit well into consumers' daily routines are more likely to be accepted, even when sustainability considerations are considered. This further supports the results of this study, showing that convenience is a critical determinant of customer intention across different countries and delivery systems. The overall findings provide significant information that may help businesses especially e-commerce business in decision making process in line to fulfilling customers demand.

In this study, Delivery Time has the most significant influence on the last-mile delivery intention, which value of Beta at 0.369, as well as evidenced by its high statistical significance ($p = 0.001$), which further supports its considerable influence. This result indicating that delivery time is the most influential characteristics that affecting customer intention to adopt sustainable last-mile delivery in the Klang Valley. This is due to the reason customers feel delivery time is very importance since the current trend and customers preferences are to receive their orders as quickly as possible. A faster delivery allows them to satisfy their needs without long waiting times and improves their overall online shopping experience. This is consistent with previous research conducted by Darren et al. (2023) that faster and more reliable delivery time significantly improves consumers' attitudes and intention to use alternative last-mile delivery methods. Dayal et. al. (2025) highlighted that parcel lockers help reduce missed deliveries and waiting time, which enhances delivery efficiency and increases users' acceptance. This highly aligns with the findings of this study, which also shows that delivery time plays a crucial role in influencing customer intention in the Malaysian context.

Distance to Pick-up Location indicated quite a high significant relationship with the customer intention in last-mile delivery usage, with value of Beta at 0.267, which is align with Zenezini et. al. (2018) and Chen et al. (2018) findings that indicated that pick-up points located in accessible and strategic locations reduce perceived time pressure and improve the overall delivery experience. Both studies have a similarity idea, where shorter distance to pick-up locations leads to higher customer intention toward sustainable last-mile delivery. However, Liu et. al. (2024) have different perspective in this matter where, the it stated that location does not have a significant direct effect on attitude toward self-service technology adoption. They believe location was treated as a perceived belief variable that influenced adoption intention indirectly through attitude, rather than having a direct effect on intention. Although location convenience is important, it may not be sufficient to directly shape the intention unless it contributes to a positive overall attitude toward the sustainable approaches.

Behavioural intention is shaped by attitudes toward the behaviour, subjective norms, and perceived behavioural control (Ajzen, 1991). The results of this study indicate that there are a few characteristics of sustainable last mile delivery including convenient delivery, environmental impact, delivery time, and distance to pick-up location. These of the characteristic can be interpreted as an important belief-based factors that influence customers' attitudes and perceived behavioural control toward sustainable last-mile delivery. To illustrate, delivery time and distance to pick-up location reflect customer's perceptions of effort, time availability, and ease of performing the behaviour, which are closely related to perceived behavioural control. When customers perceive that a delivery option is fast and that the pick-up location is close and accessible, they are more likely to feel confident in their ability to use such services, thereby strengthening their intention. While Environmental

Impact shows minor positive influence on customer intention, it still indicates that customer attitudes toward sustainable behaviour play an important role and that favourable attitudes toward behavioural in shaping their intention to last-mile delivery. By providing customers with information about the environmental and social sustainability impact of last-mile delivery options can positively influence their intention to choose more sustainable delivery methods (Kokkinou et. al., 2026; Ignat & Chankov, 2020; Salgado et. al., 2026). When customers are aware of the broader sustainability consequences of their choices, their attitudes toward sustainable delivery become more positive, leading to stronger intention.

Though its lack of statistical significance with value p at 0.200, that suggests a restricted impact in the current setting, Delivery Cost has a minor positive coefficient that implies a slight positive influence on the customer intention, perhaps due to multiple that affected heavily on the lifestyle and the economic level of the customers. It may also due to the perceived behavioral control as compared to other characteristics such as time efficiency, accessibility and environmental considerations are perceived as more important. This finding underlines the fact that it is not only important to pay attention to Delivery Time as the main characteristics, but also to apply it rightly together with what suits the customers' demand in the e-commerce business in effort to be sustainable.

Finally, these results highlight that Delivery Time as the most significant driver, with Distance to Pick-up Location factor, following by Environmental Impact and Delivery Convenience contributing less and the little influence of Delivery Cost suggesting potential customer interest and intention.

CONCLUSION

This research adds to the growing collection of study on the sustainable delivery methods, focusing on the last-mile delivery approach in e-commerce industry environment. This study also empirically provides the view from the customer perception and intention on the matter. The results indicate that Delivery Time or speed as the primary factor that is currently shape the customers preferences in sustainable delivery approach, while Delivery Cost is not surprisingly the least characteristics that influences the customers intention on sustainable delivery method. This research enhances the comprehension of customers' perspective in engaging into sustainable approach of delivery methods. The study's findings have vital implications for the expanding knowledge as well as in industry that aims for sustainable e-commerce delivery methods in specific.

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