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CÁC YẾU TỐ ẢNH HƯỞNG ĐẾN TỶ LỆ GIAO HÀNG THÀNH CÔNG TRONG LĨNH VỰC GIAO HÀNG BƯU KIỆN CHẶNG CUỐI

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Tóm tắt

Giao hàng bưu kiện chặng cuối đóng vai trò cốt lõi đối với năng suất logistics. Nghiên cứu này khám phá tám yếu tố mấu chốt ảnh hưởng đến sự giao hàng thành công. Phân tích so sánh Suzhou và Berlin cũng nhấn mạnh tác động của bối cảnh địa phương đến sự thành công. Cuối cùng, các phát hiện điều hướng chiến lược củng cố tính năng suất, linh hoạt và đàn hồi trong việc điều hành giao hàng chặng cuối.

Keywords: tỷ lệ giao hàng thành công, giao hàng chặng cuối, giao hàng bưu kiện

FACTORS AFFECTING SUCCESSFUL DELIVERY RATE IN LAST-MILE PARCEL DELIVERY

Abstract

Last-mile parcel delivery plays a vital role in modern logistics. This study explores eight key factors affecting delivery success. A comparative analysis of Suzhou and Berlin then highlights contextual impacts on performance. Finally, the findings offer strategies to strengthen efficiency, adaptability, and resilience in last-mile operations.

Keywords: successful delivery rate, last-mile delivery, parcel delivery

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1. Introduction

The growth of e-commerce has increased both the importance and complexity of last-mile delivery (LMD), making it a critical element in B2C logistics (Cardenas, 2017). Parcel shipments are expected to grow significantly from 161 billion in 2022 to 256 billion by 2027 (Statista, 2023b). Despite technological advancements, LMD remains the costliest part of the supply chain with failed first delivery attempts accounting for up to 28% of total delivery costs (Pufahl et al., 2020).

While LMD has been widely studied, existing research remains theoretical or simulation-based, lacking real-world validation. Most studies overlook the factors influencing successful delivery rates, focusing instead on cost efficiency or customer satisfaction. However, delivery success is shaped by both controllable and uncontrollable factors, making it a complex challenge.

This study addresses the gap by holistically examining both controllable and uncontrollable factors affecting parcel LMD success beyond cost-based models. The findings aim to guide businesses in developing more efficient, resilient delivery strategies and contribute to research in optimizing LMD logistics.

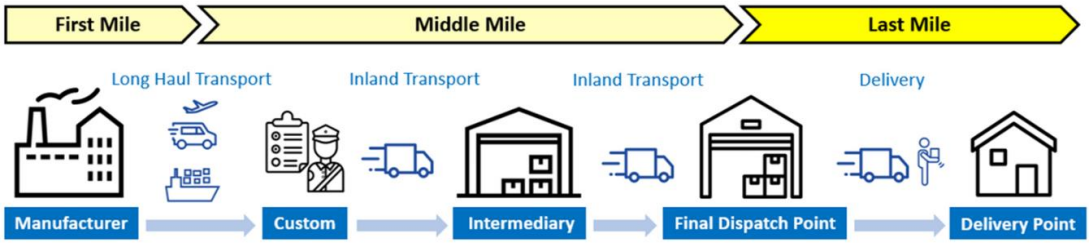
2. Theoretical basis

2.1. Last-mile delivery

2.1.1. Definition

Last-mile delivery (LMD) represents a crucial segment of the supply chain, involving the final activities necessary to transport goods from the final transit point to the destination, either the customer's home or a designated collection center (Aized and Srai, 2007).

Figure 2.1. *Last-mile delivery position in logistics*



Source: Ha et al. (2022)

In practice, LMD is instrumental across various industries. In *e-commerce*, giants like Amazon rely heavily on efficient last-mile logistics to meet customer expectations (Lim et al., 2017). *Parcel services*, led by the likes of FedEx and DHL, also hinge on the efficacy of LMD (Cortes and Suzuki, 2021).

LMD displays strong economic significance in its $140.48 billion market value in 2023, projected to reach $200.42 billion by 2027 (**Figure 2.2**). This growth reflects a continuing effort to enhance consumer satisfaction via faster delivery times (Aljohani, 2024).

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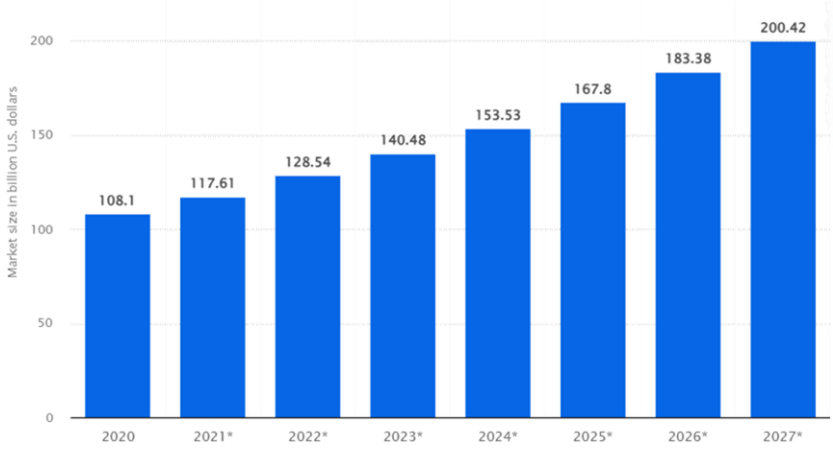
Figure 2.2. *Global LMD market size (2020-2027)*

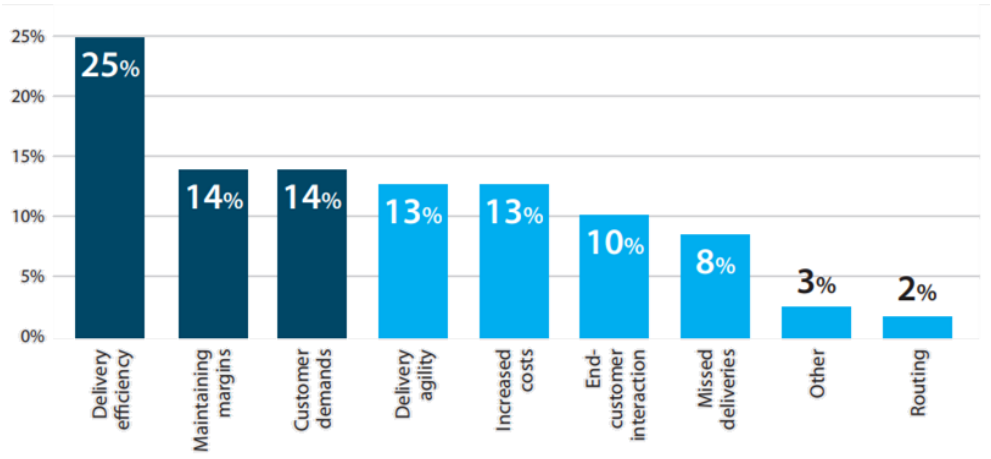


Source: Statista (2023a)

2.1.2. Challenges and future trends

The growth of e-commerce has exponentially increased the volume of orders and *heightened demand* for rapid delivery, real-time tracking and free shipping (14%) (Corejova et al., 2022). *Cost management* represents another significant challenge, ranked equally important alongside delivery agility (13%). Placek (2022) finds that it represents 41% of the overall shipping costs, which are inflated by packaging, fuel, labor, and the complexity of delivery routes, etc. *Missed deliveries* (8%) combined with *product returns* (as high as 30%) further introduce logistical complexity (Newcastle Systems, 2023).

Figure 2.3. *Biggest challenges for logistics providers in LMD*



Source: EFT (2018)

In recent years, bike couriers and crowd-sourcing deliveries have emerged as significant trends in response to increasing traffic congestion and consumer demand for quick, flexible LMD (Jawali and Ramya, 2024). A prominent future trend is the use of autonomous and semi-autonomous vehicles, which aim to reduce dependence on human resources. Besides, by 2040, the goal is for all LMD to be conducted by green-energy electric vehicles (Möller, 2023).

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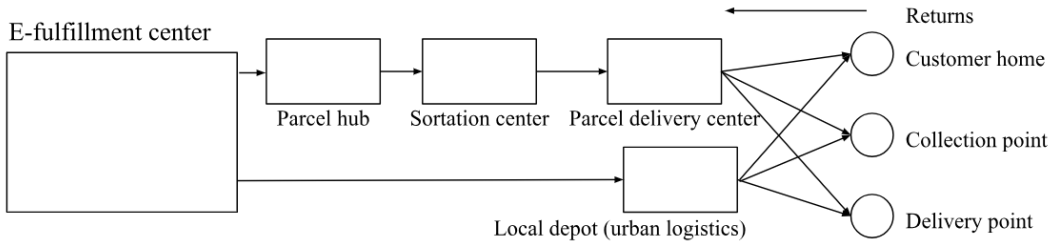
2.2. Parcel delivery

Parcel delivery refers to the transportation of lighter packages (<70kg), grouped into larger units based on their destinations (Aranko, 2013). The rise of e-commerce and home shopping has significantly boosted demand for B2C parcel delivery services, catching up to the once B2B-dominated industry, with projected growth to $474.15 billion in 2024 (The Business Research Company, 2024).

The process of B2B e-commerce distribution (**Figure 2.4**) begins with e-commerce parcels being collected from vendors to a centralized e-fulfillment center, and continues through layers of hubs and sortation until the final stretch, where couriers deliver the parcel to the final consumer. In this study, *"last-mile parcel delivery"* shall be defined as the transportation of parcels from the final delivery hub to a collection point or the recipient's address.

Figure 2.4. *E-Commerce B2C Distribution*



Source: JLL (2013)

E-commerce B2C parcel delivery possesses significantly different characteristics from traditional B2B delivery (**Table 2.1**). B2C parcel LMD is notably more expensive due to the dispersed, smaller-size and high-frequency orders (Gevaers et al., 2011). Joerss et al. (2016) of McKinsey estimates LMD to account for over 50% of parcel delivery expenses. Therefore, first-time delivery success is pivotal to generate profit.

Table 2.1. *Traditional B2B delivery and E-commerce B2C delivery*

Attributes	B2B	B2C
Shipment type	Large, homogenous	Small, heterogeneous
Delivery stops	Few	Many
Time sensitivity	Low	High
Delivery failure	Few	Many
Delivery cost per load	Small	High

Source: Xing et al. (2011)

Successful delivery rate, commonly referred to as "success rate", "hit rate", "first-attempt rate", is not well-defined in existing literature. Florio et al. (2018) considers delivery successful if the customer is available to receive the parcel at the moment the courier visits. Furthermore, Rao et al. (2014) posits that a successful delivery should prevent customers from product returns. Similarly, Younus et al. (2023) considers an order

failed in cases of unavailability for receipt and rejection of order. In this paper, delivery is considered successful if it satisfies the following criteria partly based on the Rights of Logistics:

- *The parcel is delivered to the correct address of the customer;*
- *The parcel is delivered at the correct time when the customer is available for receipt;*
- *The parcel is delivered in the correct condition, without apparent damages;*
- *The parcel is delivered with the correct products and quantities ordered.*

3. Factors affecting parcel LMD success rate

3.1. Theoretical model

This report uses a qualitative approach combining literature review and cross-referencing secondary statistics to identify factors that may affect the success rate of last-mile parcel delivery. From 32 research articles, 8 major groups of determinants were derived (**Table 3.1**).

Table 3.1. *Major factors affecting parcel LMD success rate*

Factor	Source	Description
Nature of goods	George and Iravo (2014), Senthil and Muthukannan (2021), Suguna et al. (2021), Izadkhah et al. (2022), Kithu and Kamau (2022), Alidaee et al. (2023)	Characteristics of a parcel affect the parcel's conditions throughout delivery.
Delivery density	Park and Regan (2004), Jiang et al. (2019), Le and Ukkusuri (2019), Amaral and Cunha (2020), Suguna et al. (2021), Lyons and McDonald (2022)	Delivery density influences the speed and frequency of delivery.
Business facility	George and Iravo (2014), Bopage et al. (2019), Lyons and McDonald (2022), Schaumann et al. (2023)	Business facilities influence the speed, safety and accessibility of delivery.
Routing technology	Liong et al. (2008), Jiang et al. (2019), Suguna et al. (2021), Puri (2022), Yu et al. (2022), Schaumann et al. (2023), Caldarone (2024)	Routing technology influences the speed and accuracy of delivery.
Delivery workforce	Bopage et al. (2019), Suraihi et al. (2021), Rivell (2024)	The workforce influences the speed and safety of delivery.

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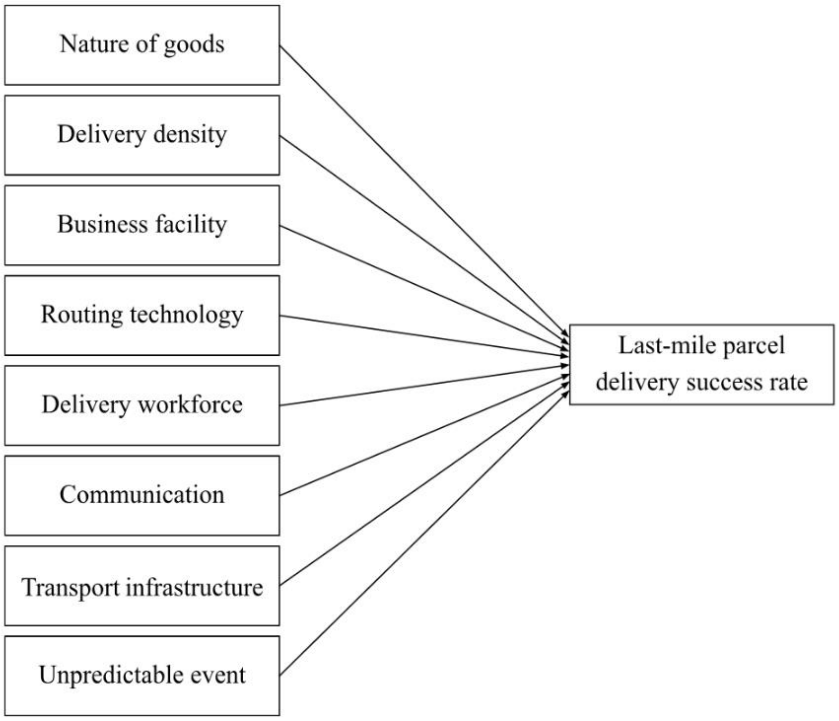
Communication	Rajesh and Ravi (2015), Matuszczak and Chrąchol-Barczyk (2016), Bopage et al. (2019), Li and Palanisamy (2019), Holloway (2024)	Communication between parties influences the seamlessness of delivery.
Transport infrastructure	Palma and Lindsey (2009), Quak and Koster (2009), McCallum (2020), Pirra et al. (2021), Laynes-Fiascunari et al. (2023)	The road and traffic infrastructure influences the speed, accessibility of delivery.
Unpredictable event	Arıkan et al. (2014), (Syrmos et al., 2023)., Mike (2014), Pirra et al. (2021), Pleeth (2023), Raj et al. (2023)	Unpredictable events affect all aspects of delivery.

Source: Authors composed

With secondary data gathered from renowned, publicly available sources e.g. Parcel Monitor, KPMG, McKinsey, each factor (**Figure 3.1**) shall be cross-referenced to find indications of potential impact on the success rate of last-mile parcel delivery for future research.

Figure 3.1. *Theoretical model of impact*



Source: Authors composed

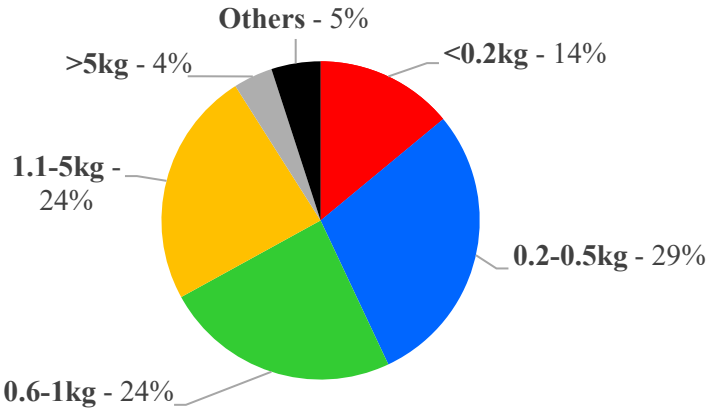
3.2. Nature of goods

George and Iravo (2014) highlight several characteristics impacting delivery success: weight, shape, unitization, perishability, and form of products.

- *Weight and shape*

Heavier or bulkier items may require larger storage space, limiting the number of units that can be transported in a single trip. Similarly, irregularly shaped products might reduce the ability to fully optimize vehicle storage (George and Iravo, 2014).

Figure 3.2. *Average weight of packages delivered (2021)*



Source: Statista (2024a)

On average, the majority of parcels delivered are lighter weight (≤1kg), which are more suitable for handling and transportation (**Figure 3.2**). In contrast, heavier or bulkier items are intensive and vulnerable (Fareye, 2022), degrading the quality and LMD success rate.

- *Unitization*

The current issue with parcel LMD lies with loading items of incompatible dimensions. According to Senthil and Muthukannan (2021), product unitization is assembling a product into distinctive batches with uniform dimensions. Unitized packages shorten handling time and decrease risk of damage, increasing the successful delivery rate (Kithu and Kamau, 2022).

- *Perishability*

Perishable goods involve specific time and temperature control to retain freshness and quality throughout the delivery. Failure to maintain proper temperature or prolonged delivery times can result in product spoilage, hence unsuccessful delivery. The rate of damage and spoilage for perishable products during LMD is estimated to be 5-20%, particularly when temperature controls are inadequate (Buss, 2022).

- *Form*

The form of a product influences how items are handled, transported, and delivered. Solids are the simplest to handle and transport, but fragile goods may require additional protective measures (Alidaee et al., 2023). Liquids could also face problems during the delivery like leakage and spoilage (Ryan, 2017).

Consequently, the authors suggest: *Nature of goods positively correlates with last-mile parcel delivery success rate.*

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3.3. Delivery density

Compared to B2B delivery, e-commerce LMD systems present a greater delivery density (number of nodes) per area, exposing the system to longer transit time, causing delays and mis-timings (Amaral and Cunha, 2020).

From data of parcel deliveries per capita, the delivery density within 1km² is estimated (**Table 3.2**). USA, Canada, who have high delivery success rates (Parcel Monitor, 2024), exhibit the lowest parcel density. Meanwhile, Japan with high redelivery rates (Kise and Masuda, 2022), harbors the densest parcel network (66 parcels/km²/day). Nevertheless, outliers (Australia, Brazil) indicate delivery density may not be entirely deterministic of successful delivery.

Table 3.2. *Parcel delivery density (2023)*

Country	Packages ≤31kg per km² per day
Japan	66
UK	58
China	33
France	9
USA	7
Australia	1
Canada	1
Brazil	1

Source: Based on Pitney Bowes (2023)

To reduce lead time without sacrificing costs, collection points and parcel lockers effectively condense many delivery nodes into a select few. Europe is the most rapid adopter (**Table 3.3**), with 120,390 automated parcel machines and more than 336,000 pickup points (Vargas, 2024). France and the UK's wide adoption of innovations (45,000 and 52,000 respectively) may explain their high delivery success rate, despite their high density.

Table 3.3. *Parcel locker and Collection point usage (2021)*

Region	Parcel locker usage	Collection point usage
Europe	1.48	3.6
North America	0.75	1.93
Asia	0.07	0.82

Unit: % of Total LMD

Source: Hudson (2021)

Consequently, the authors suggest: *Delivery density negatively correlates with last-mile parcel delivery success rate.*

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3.4. Business facility

Business facility either facilitates or constrains the effectiveness, speed, and safety of logistics. Such facilities may include the availability of regional depots, the mode of transport and material handling technology (George and Iravo, 2014).

- *Regional depots*

Delivery depots/hubs are transshipment points where deliveries are cross-docked onto smaller vehicles (Danielis et al., 2010). The number of hubs and the proximity to customers likely correlates with delivery success rate (Simoni et al., 2018). To illustrate, Malaysia had 385 hubs in 2023 (Siddharta, 2023). Based on the total residential area, each hub likely serves a short radius of 7.4km, allowing for a 94.3% success rate in 2023 (Parcel Monitor, 2024).

To utilize this relationship, for instance, the mobile micro-hubs system uses a large vehicle as a depot in urban centers from which delivery drones will carry parcels to their destination (Zieher et al., 2024). This system is expected to increase delivered packages by 240% compared to conventional trucking.

- *Transport vehicles*

The number of delivery vehicles available increases the number of orders that can be carried out simultaneously. As demand for parcel delivery grows, so does demand for delivery vehicles to expand capacity. The recognized role of fleet size is evident with the parcel delivery vehicles volume in China reaching 237,000 vehicles in 2019 (TPRI, 2022).

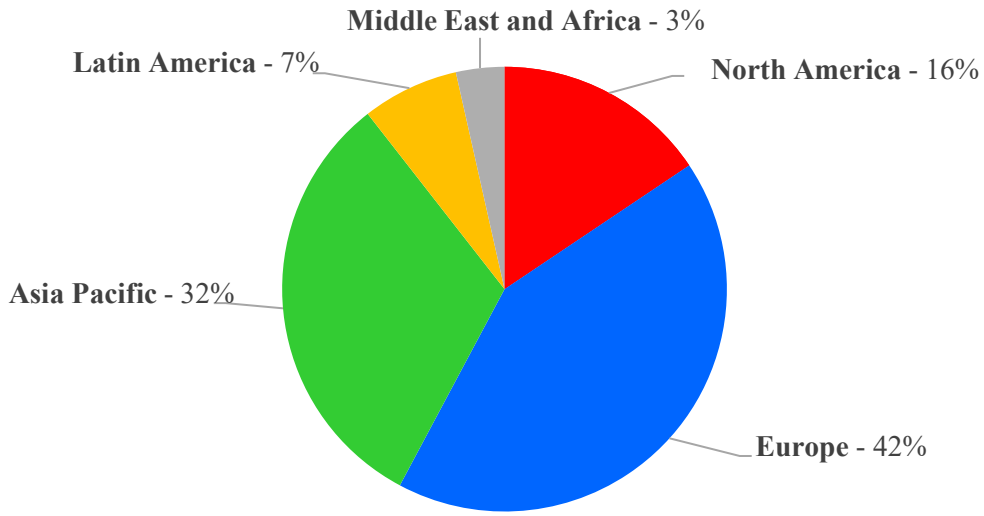
Four primary modes of LMD include: four-wheelers, two-wheelers, drones, and robots, each with distinct characteristics. **Figure 3.3** highlighted the accessibility differences. Four-wheelers can only access large roads during certain hours, while walking robots and drones can bypass most infrastructural constraints.

Figure 3.3. *Accessibility for different types of vehicles*

Source: Himstedt and Meisel (2024)

Light vehicles have long been considered for LMD thanks to their adaptability to sparse parking space and deep alleys. The high delivery success rate of Europe, Asia Pacific, and North America compared to Latin America's lower success rate mirrors their share in cargo bike investment (**Figure 3.4**).

Figure 3.4. *Global cargo bike market share (2022)*



Source: Coherent Market Insights (2024)

Li et al. (2020) suggest drones to be the most economical and time-efficient, thus regions with high concentration of delivery drones may witness higher success rates. MarketsandMarkets (2024) reports the 2023 delivery drone market to be evenly distributed between North America, Europe, and Asia Pacific (32% each), who also recorded high delivery success rate (Parcel Monitor, 2024), in contrast to Latin America's limited contribution and lower success rate.

- *Material handling technology*

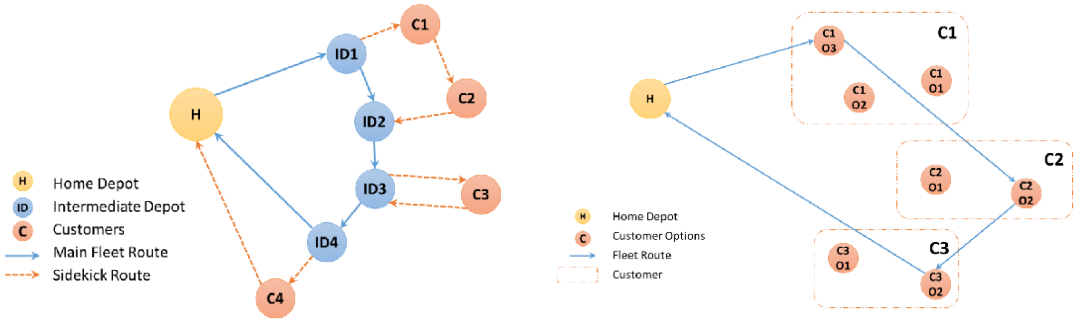
Tadić et al. (2023) opines that reliable LMD is a function of material handling via handling time, delivery errors and damage to goods. At robust depots, conveyor systems sort and move parcels onto LMD vehicles, expediting handling and reducing human error (Haneyah et al., 2013). Meanwhile at smaller hubs, manual handling alone may be sufficient. The high investment of the top three regions and correlation with successful delivery rate in 2023 may point to material handling being a factor of LMD (Precedence Research, 2024).

Consequently, the authors suggest: *Business facility positively correlates with last-mile parcel delivery success rate.*

3.5. Routing technology

The Vehicle Routing Problem (VRP) is a fundamental optimization problem in determining the most efficient delivery routes while adhering to specific constraints (Demir et al., 2022). In reality, delivery challenges require dynamic adaptations to customer requests, traffic conditions and time sensitivity.

Figure 3.5. *VRP with sidekick (a) & VRP with optional points (b)*



(a) (b)

Source: Jazemi et al. (2023)

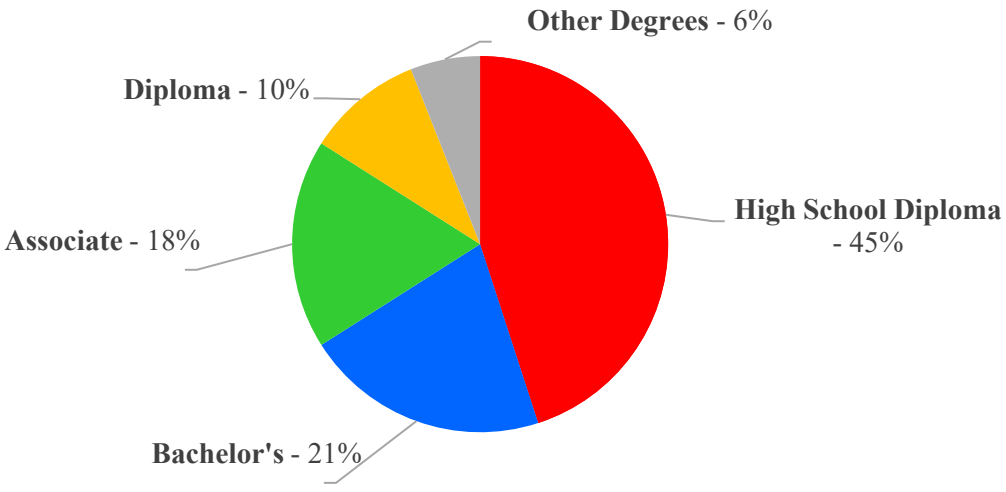
Emerging delivery models expand VRP applications (**Figure 3.5**). Drones can handle deliveries from mobile hubs, offer speed and flexibility while bypassing congestion (Wang and Sheu, 2019). Meanwhile, delivery to optional points prioritizes customer preferences, reducing mis-deliveries and detours.

Consequently, the authors suggest: *Routing technology positively correlates with last-mile parcel delivery success rate.*

3.6. Delivery workforce

The delivery workforce forms the backbone of LMD. Consistency and reliability in delivery operations require a stable, experienced workforce. High turnover rates disrupt operations as new hires demand copious training (Suraihi et al., 2021). Ongoing training programs are equally crucial, ensuring swift response to industry innovations and customer expectations.

Figure 3.6. *Delivery driver educational attainment in the USA*



Source: Zippia (2021)

Workforce demographics highlight several advantages. In the USA, delivery drivers are relatively mature, with an average age of 34 for men and 32 for women. 45%

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of USA delivery workers have high school diplomas, and 21% possess bachelor's degrees, equipping them to adapt to changing technologies and customer needs (**Figure 3.6**).

The workforce must also be adequately scaled to meet demand surges during peak periods. For instance, Black Friday see massive spikes in parcel volumes that strain delivery networks (Rivell, 2024). Against workforce shortages, crowdsourcing has emerged as an effective solution. By matching workers with jobs based on availability and location, firms can efficiently allocate tasks while rapidly scaling capacity.

Consequently, the authors suggest: *Delivery workforce positively correlates with last-mile parcel delivery success rate.*

3.7. Communication

Effective communication among logistics providers, delivery workers, and customers is essential for LMD (Sanina et al., 2017). Key communication challenges include inconsistent tracking, unattended home deliveries, and untimely notifications (Muhammad et al., 2022).

In response, a variety of communication channels are used. SMS and email notifications keep customers updated on delivery progress and allow them to plan ahead. Mobile apps offer real-time tracking, messaging and delivery preferences. Phone calls address urgent scenarios requiring customized resolutions. Advanced tools like UPS MyChoice further empower customers to manage deliveries.

Yet, >63% of carriers report unattended home deliveries as a significant issue. ETA notifications and two-way messaging mitigate this problem by allowing rescheduling or providing delivery instructions (Silva et al., 2008).

Consequently, the authors suggest: *Communication positively correlates with last-mile parcel delivery success rate.*

3.8. Transport infrastructure

Transport infrastructure underpins LMD by supporting transportation networks, traffic conditions, and regulatory environments (Mohd Rohaizad et al., 2021). Robust road infrastructure combats the major obstacle of congestion, while poor parking infrastructure may exacerbate delays. For instance, delivery vehicles in Seattle spend 28% of their time searching for parking spots (Carnegie Mellon University, 2023).

Rural areas face unique challenges stemming from insufficient infrastructure. Many rural routes rely on unpaved roads, hindering delivery speeds, unideal for time-sensitive goods (Dipeolu, 2022). Rural digital connectivity often lags as well, limiting implementation of real-time tracking and dynamic routing (Liang and Chen, 2021).

Table 3.4. *Successful Delivery Rates and GQII Rankings of some countries*

Country	Successful Delivery Rate	GQII Ranking
Switzerland	97.5%	16
The Netherlands	97.2%	19
Canada	92.5%	13

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Venezuela	87.7%	136

Source: GQII (2023), Parcel Monitor (2024)

The Global Quality Infrastructure Index (GQII) showcases how well-developed infrastructure correlates with delivery success. For example, Switzerland and the Netherlands, ranked 16th and 19th on the GQII, boast success rates above 97% due to extensive road coverage and urban mobility systems (**Table 3.4**). Conversely, Venezuela, ranked 136th, sees lower success rate due to poor infrastructure and regulations.

Consequently, the authors suggest: *Transport infrastructure positively correlates with last-mile parcel delivery success rate.*

3.9. Unpredictable event

LMD operations often face external challenges beyond control, e.g. traffic congestion, extreme weather, and unexpected vehicle malfunctions, which can significantly disrupt delivery schedule and success rate (Syrmos et al., 2023).

The major challenge is traffic congestion: even a minor incident can substantially delay multiple deliveries along the same route. In major USA cities, traffic congestion is progressively worsening, leading to more unsuccessful LMD (Islam, 2019). The number of delivery vehicles in major cities is projected to rise by 36% by 2030, lengthening average commute by 11 minutes (WEF et al., 2020).

Extreme (e.g. hurricanes and snowstorms) and even moderate weather conditions (e.g. rain, fog, or hail) can cause delays, reduce visibility, and damage products and infrastructure (Pleeth, 2023). This requires specific contingency plans to ensure safe LMD operations.

Consequently, the authors suggest: *Unpredictable events negatively correlate with last-mile parcel delivery success rate.*

4. Insights from Case of Suzhou and Berlin

4.1. Analysis of Suzhou and Berlin

Suzhou, a key player in China's booming parcel industry, handled 1.73 billion parcels in 2019 (+39% YoY), generating CN¥21.68 billion in revenue (TPRI, 2022). Suzhou's success stems from a combination of technological advancements and a robust road network that supports its urban and rural logistics.

The city's extensive road network spans 11,818km, with a highway density of 139.2km per 100km², smoothing parcel distribution between urban and rural areas. Suzhou's fleet includes 52,915 delivery vehicles, and 13,900 electric tricycles equipped with GPS tracking. Suzhou's policies, guided by the "Postal Law" and green development goals, focus on LMD efficiency, which are further boosted by 2,955 parcel stations (1,024 in rural areas) and 9,331 smart lockers.

Berlin, meanwhile, represents a sustainability-focused model in Europe's €23.5 billion parcel industry (Statista, 2024b). Berlin's Courier, Express, and Parcel sector relies heavily on light commercial vehicles (66% of the fleet). The city's Clean Air Plan limits fossil-fueled vehicles in low-emission zones, prompting logistics firms to adopt electric

vehicles (Collins, 2023). With over 5,000 electric vehicles and programs like KoMoDo's shared micro-depots, Berlin's LMD reduces emissions while maintaining efficiency. Innovations e.g. cargo bikes and mini EVs further optimize deliveries in dense urban environments.

Regardless, Berlin's transport infrastructure faces significant challenges. Poor parking space location forces couriers to walk additional distances, raising lead times (McLeod et al., 2020). Initiatives like Green City Plan address such issues by expanding electric vehicle zones and refining urban logistics planning. Berlin also optimizes delivery density through a network of 2,793 pickup points, with 150–275 locations per district. Centralized parcel lockers reduce delivery errors and mileage. For example, DHL's strategic routing reduced total mileage within Berlin by 26% (Leerkamp et al., 2020).

4.2. Takeaways for successful LMD systems

First, business facilities must align with a city's logistical needs and environmental priorities. Suzhou relies on scalability, high-capacity fleets and sorting technologies to manage vast parcel volumes. Berlin emphasizes sustainability, using electric vehicles, cargo bikes, and micro-depots to meet stringent emissions requirements.

Second, infrastructure plays a central role in shaping delivery efficiency. Suzhou's extensive highway network connects urban and rural areas seamlessly, whereas Berlin mitigates constraints with zoning policies, e-mobility adoption, and innovative delivery methods.

Finally, delivery density strategies should consider urban layouts. Suzhou bridges its urban-rural divide through extensive parcel lockers, ensuring equal service access, while Berlin's dense pickup-point network caters to urban districts. Cities with rural populations can adopt Suzhou's model, while high-density urban centers can replicate Berlin's clustering approach.

5. Discussion, Recommendations and Limitations

This study presents a comprehensive overview of factors influencing parcel LMD success, highlighting controllable (business facility, workforce, routing technologies, and communication) and uncontrollable elements (nature of goods, delivery density, transport infrastructure, and unpredictable events). For instance, lighter packages and robust infrastructure tend to support efficient delivery, unlike perishable items, poor roads, and high density.

To improve delivery success, companies should focus on strategically located hubs, a diverse fleet of vehicles, advanced routing systems and communication channels with customers. Additionally, solutions like micro-hubs, crowdsourced delivery, and parcel lockers can mitigate challenges from uncontrollable factors. Although unpredictable disruptions are inevitable, a flexible workforce and contingency plans can minimize their impact.

Nevertheless, the study is based on secondary data and urban case studies, which may limit its wider application. Future research should explore different regions, product

types, and incorporate relevant technologies. A quantitative, data-driven approach could also help clarify the interactions between these factors.

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