

2023 Global Smart Last-Mile Logistics Outlook



Abstract

With continuous upgrading of technology, deeper integration of intelligent technologies, industrial scenarios and wider industrial application, recent years we have witnessed the booming development of smart last-mile logistics represented by **smart PUDOs, smart locker banks, unmanned vehicles and drones**.

There are two primary driving factors behind it. **Firstly**, the contradiction between supply and demand is becoming increasingly serious. Along with aging, the increasing labor cost and the high mobility of couriers make employment more difficult. Under the background of the growing e-commerce demand and parcel volume, a more efficient way is needed for last-mile delivery. **Secondly**, the diversity of consumer demand increases. In addition to the requirements for convenience and flexibility of parcel pick-up, consumers are considering solution diversity, environmental protection, and sustainable development.

Against the above backdrop, we summarize **the advantages of smart last-mile logistics from the perspective of "4E"**:

- **Experience:** Improve consumer experience, and realize the convenience, time flexibility, and choice diversity of parcel pick-up.
- **Enablement:** Enrich solution diversity and improve the effectiveness of solutions such as return service and efficient delivery.
- **Expenditure:** Reduce costs and increase efficiency, ultimately reduce labor expenditure.
- **Environment-friendliness:** Help the enterprises and customers in their pursuits of environment-friendliness and sustainable development.

In fact, smart last-mile logistics have been rapidly growing. The global CEP market has been growing at about 10% over the past few years, which is bound to further expand the smart last-mile market. Europe's OOH (out-of-home delivery) network increased by about 35% in 2021. Southeast Asia, the Americas, and other places are embracing greater smart last-mile opportunities. As is all known an optimal OOH network location is a scarce resource that requires planning and quick action. Therefore, at this stage, smart last-mile logistics can no longer be ignored by logistics enterprises, e-commerce companies and other relevant players.

As a result, we have set out with a global perspective to build a **Smart Last-Mile Logistics Market Assessment Model**. Based on two dimensions of market attraction and maturity, we divided the selected key countries into three groups – key benchmark markets, potential growth markets and sub-potential incubator markets, and discussed the strategies they adopted for developing smart last-mile logistics.

Additionally, we've selected three representative countries for detailed analysis. As one of the key benchmark markets, China has highly mature smart last-mile logistics, and its digital technology and experience could also serve as a valuable reference. For example, smart last-mile logistics in China demonstrate digital intelligence with all elements and in all processes. The core sections of smart PUDOs have already achieved intelligence and digitalization, including inbound, monitoring, pick-up, and unmanned vehicle delivery. In the European market, we select Poland whose rapid development of smart last-mile logistics is noticeable, especially that of its locker banks. Its business model in particular, has aspects to

emulate. We have selected Singapore for analysis in Southeast Asia, representing highly urbanized markets. The application of smart last-mile logistics is a general trend due to growing high labor costs and increasing parcel volume.

Technology will continue to change our life. Looking ahead, smart last-mile logistics will continue to develop to better suit user scenarios in the future. Consumers are not the only ones who stand to benefit from intelligent technology, the market participants will also gain a place in the tidal wave of technology. They will be able to develop their competitive advantages through clear insights and active participation. Smart last-mile service

providers can offer a combination of intelligent solutions to meet the demands of consumers in specific markets. Players such as logistics companies and e-commerce platforms may first consider their position, goals, local market characteristics and consumer preferences when choosing appropriate solutions. Secondly, players are encouraged to carry out last-mile network expansion planning based on relevant data, and conduct multi-dimensional evaluations based on different factors, such as the "4E". Finally, long-term and short-term interests need to be balanced to decide how to participate, for example, decide between self-owned and leasing.



The smart last-mile logistics will greatly improve consumer experience and help solve the problem of last-mile delivery being the biggest cost driver in the whole logistics process. For core last-mile logistics players, it is increasingly important to seize the opportunities in the new era and upgrade themselves through smart means so as to build competitive advantages.



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Under the quick development of demand and new technology, the evolution of global smart last-mile solutions will be strongly promoted by logistics ecological partners to improve the efficiency and reduce cost.



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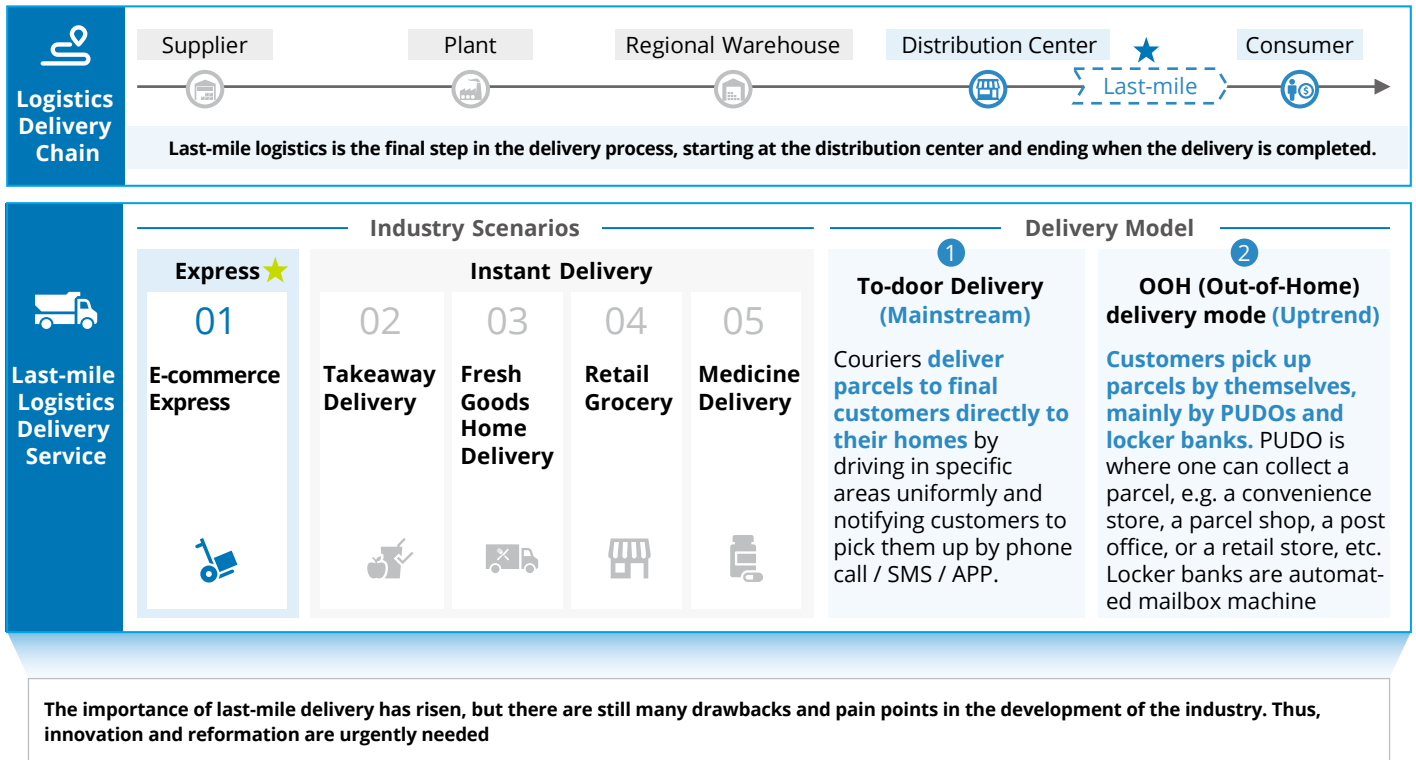
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1. Background of global smart last-mile logistics



1.1 Research scope, definition, mode, and scenario of last-mile logistics

Figure 1: Overview of global last-mile logistics distribution



The importance of last-mile delivery has risen, but there are still many drawbacks and pain points in the development of the industry. Thus, innovation and reformation are urgently needed. The global average cost of last-mile logistics delivery accounts for 41% of the total delivery cost (Figure 2). Meanwhile, low efficiency and the single mode cannot meet consumers' increasingly diversified needs.

In the future, last-mile delivery will focus more on user experience, cost

reduction and efficiency improvement through technological transformation across different scenarios. Besides, intelligentization has become a differentiation strategy and business growth point for the players. In the overall construction of a smart last-mile logistics ecosystem, consumers, logistics enterprises, e-commerce platforms, governments, and technology service enterprises will play vital roles in jointly promoting the new technologies and solution innovation to comprehensively develop the last-mile industry.

Definition of last-mile logistics: In the entire logistics distribution process chain from supplier to consumer (Figure 1), the last step in the supply chain operation is defined as the last-mile logistics. The last-mile logistics delivery mainly refers to activities that directly meet the customers' needs in the last section of logistics distribution.

The delivery mode of last-mile logistics is mainly divided into two types: To-door delivery mode and OOH delivery mode.

- **To-door delivery mode** mainly refers to the method by which couriers deliver parcels to final customers directly to their homes by driving in specific areas uniformly and notifying customers to pick them up by phone call / SMS / APP. This is currently the main last-mile delivery model in most countries.
- **OOH (Out-of-Home) delivery mode** refers to the mode in which customers pick up parcels by themselves, mainly by PUDOs and locker banks. PUDO is where one can collect a parcel, which can be a convenience store, a grocery store, a parcel shop, a post office, or a retail store (click & collect). Locker banks are automated mailbox machine that allows users to pick up and drop off parcels by themselves.

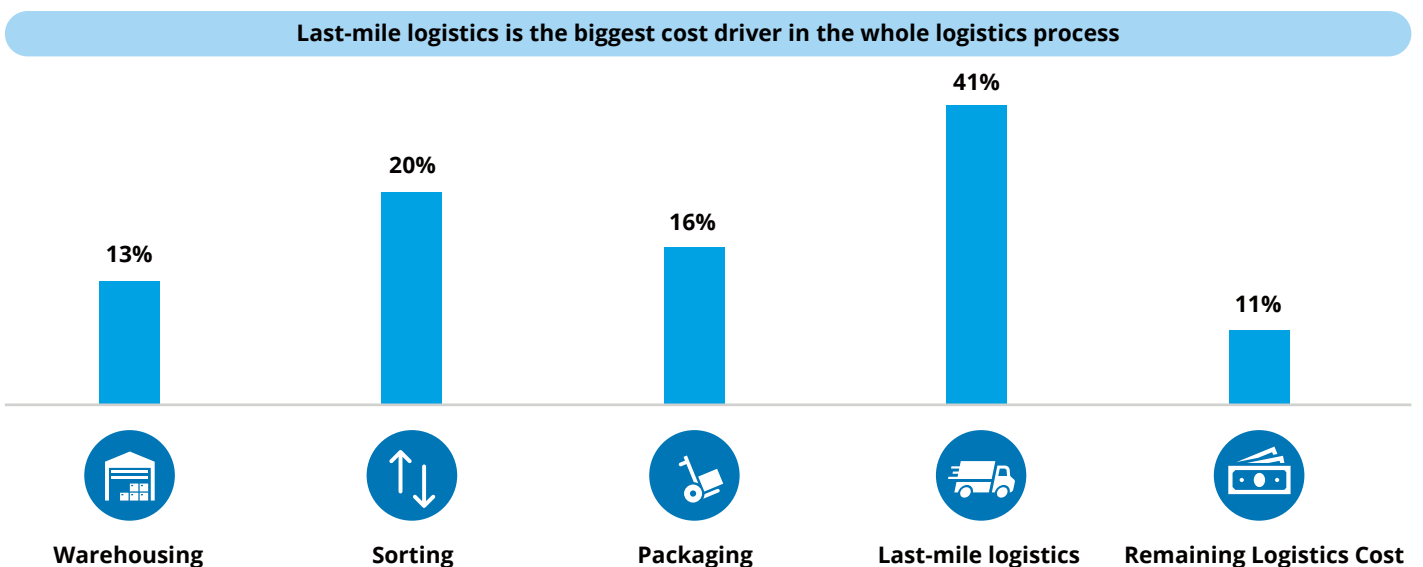
This model has developed fast and expanded steadily all around the world in the past few years. Many e-commerce platforms and logistics companies have also stepped into the OOH delivery mode service to improve customer satisfaction. They have successively launched smart PUDOs and locker banks as last-mile delivery stations. The solution with OOH delivery mode not only saves the delivery cost but also provides customers with a "24/7" pick-up service.

Last-mile logistics delivery scenarios are mainly divided into express delivery and instant delivery. Express delivery is dominated by the delivery needs of goods sent out by "e-commerce platform orders" while

instant delivery involves the demand of various industries and consumers, which covers catering, catering raw materials, retail, and medicine, which corresponds to the delivery scenarios of "takeaway delivery", "fresh home delivery", "supermarket retail", and "medicine delivery".

The research scope of smart last-mile logistics covered by this report: This white paper will focus on the scenario of e-commerce express delivery to conduct specific smart last-mile logistics application analysis, market discussion and insight sharing, but will not elaborate on the smart solutions of instant delivery including takeaway delivery, fresh food home delivery, supermarket retail, or medicine delivery.

Figure 2: The cost of last-mile logistics



Data Source: Deloitte analysis, Cainiao Research Center

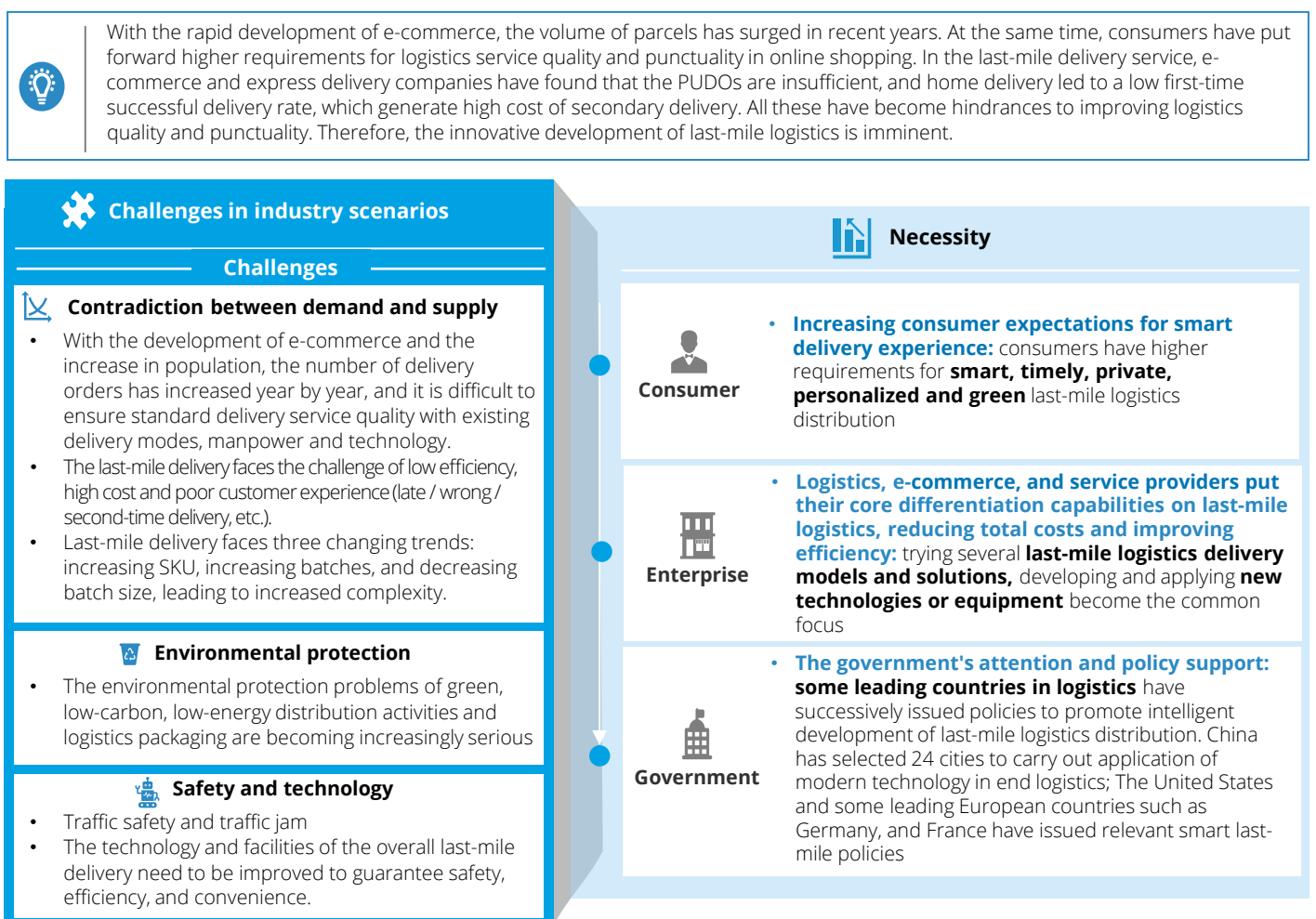
1.2 Smart last-mile logistics is imperative

Background of smart last-mile delivery's development (Figure 3): With the rapid development of e-commerce, the volume of parcels has surged in recent years. At the same time, consumers have put

forward higher requirements for logistics service quality and punctuality in online shopping. In the last-mile delivery service, e-commerce and express delivery companies have found that the PUDOs are insufficient, and home delivery led to a low first-time successful delivery rate, which

generate high cost of secondary delivery. All these have become hindrances to improving logistics quality and punctuality. Therefore, the innovative development of last-mile logistics is imminent.

Figure 3: Smart last-mile logistics is imperative



For the scenario of e-commerce express, the main challenges currently facing are:

- Contradiction between demand and supply:** With the development

of e-commerce and the increase in population, the number of delivery orders has increased year by year, and it is difficult to ensure standard delivery service quality with existing delivery modes, manpower and

technology. The turnover rate of last-mile couriers in the overall market is high, and there are challenges, such as difficulties in employment and increasing labor costs year by year.

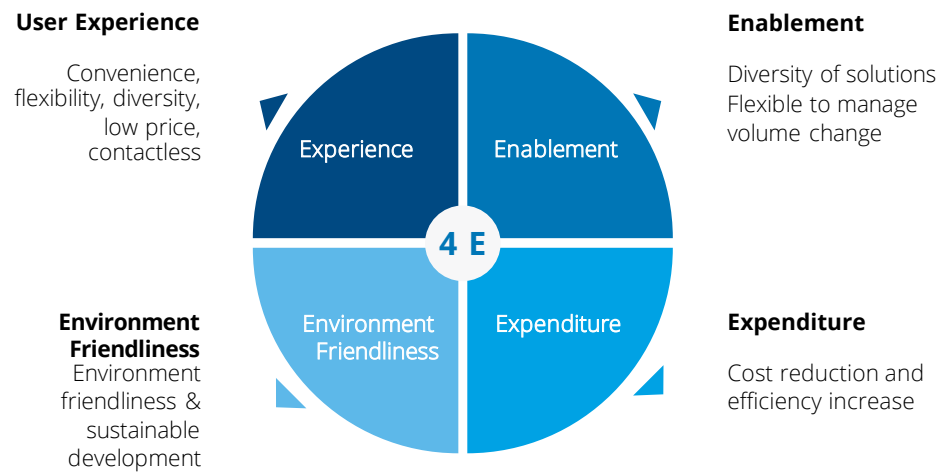
As a result, the last-mile delivery faces the challenge of low efficiency, high cost and poor customer experience (late / wrong / second-time delivery, etc.). At the same time, last-mile delivery faces three changing trends: increasing SKU, increasing batches, and decreasing batch size, leading to increased complexity.

- **Environment protection:** Government regulators, society and consumers are increasingly calling for green, low-carbon and low-energy consumption of logistics and distribution, and how to improve distribution efficiency and reduce comprehensive energy consumption has become a problem that needs to be addressed in the future.

- **Safety and technology:** In some countries such as China, last-mile delivery faces traffic safety challenges caused by unsafe three-wheel vehicles and traffic jams. The technology and facilities of the overall last-mile delivery need to be improved to guarantee safety, efficiency, and convenience.

In response to the many major challenges in the above scenarios, as well as the needs of consumers and enterprises' business development, the necessity of promoting the smart last-mile logistics delivery is underlined from the following four aspects (4E Model):

Figure 4: "4E" Model



- **Experience:** Consumer expectations for smart delivery experience are increased, such as punctuality of last-mile delivery, information privacy, flexibility, 24/7 convenience, long period of storage, low price, simple return, etc. In general, consumers need more control through visibility and service flexibility.
- **Enablement:** Enterprises develop core differentiation capabilities in last-mile logistics to compete with others. With smart OOH, enterprises can not only provide return service and other innovative solutions, but also directly understand customer

needs, and establish the entrance of comprehensive services, which is the key to competing for customers.

- **Expenditure:** Increasing pressure of supply and demand requires more considerations to expenditure. It's a good way to solve the contradiction between the long-term population pressure, the difficulty of employment and the growth of express parcels.
- **Environment-Friendliness:** Governments, enterprises and individuals throughout society are paying more attention to sustainable

development issues such as environmental protection and traffic jam reduction.

We also noticed that the governments have issued relevant policies to promote logistics efficiency and comprehensive emission reduction in the whole society:

- **China has attached great importance to the development of last-mile delivery in recent years:** At the national level, in 2018, the General Office of the State Council issued the *Opinions*

on *Promoting the Coordinated Development of E-commerce and Express Logistics* (hereinafter referred to as the Opinions), which clarified six major policies to help the coordinated development of e-commerce and logistics express: optimize the policy and regulatory environment for coordinated development; improve e-commerce express logistics infrastructure; optimize the traffic management of e-commerce delivery; improve the last-mile service capacity of express delivery; strengthen standardization and intelligence, and improve the efficiency of collaborative operation; strengthen the green concept, and develop a green ecological chain, etc. The Opinions made it clear that service innovation should be strengthened, and the last-mile service capacity of express delivery should be improved. The Opinions encouraged the integration of smart express boxes into convenience services and livelihood projects, and the adoption of other smart delivery facilities. Besides, the effective organization and integrated utilization of last-mile delivery, service resources and intensive services were also promoted.

- **The United States is leading in the development of policies for**

unmanned vehicles in the last-mile logistics delivery and divides unmanned delivery products into two categories according to size for management. One is personal delivery equipment (PDD), and the other is managed as low-speed motor vehicles. Since 2017, various states have successively issued PDD regulations to regulate small-size unmanned delivery vehicles driving on sidewalks. The motor-driven driverless delivery vehicle needs to apply for a test license under relevant regulations. When the unmanned delivery low-speed vehicle without a cab is deployed on a large scale, it is necessary to submit an exemption application to the NHTSA of the US Department of Transportation. In 2022, NHTSA issued the first *Passenger Protection Regulations of Driverless Cars* to further boost the development of vehicle automation and the popularization of commercial applications.

- **France, Germany, and other leading countries in logistics development** have also introduced a series of regulations and supporting policies to support smart last-mile logistics applications. In 2021, France proposed an accelerating green and smart logistics development strategy. It would spend 200 million euros

on the construction of automated, interconnected, and low-carbon transport service infrastructure and another 90 million euros for the construction of "logistics 4.0" projects, strengthening the construction of hardware facilities for logistics methods such as delivery robots and drones. In 2019, several German government departments jointly launched the *Logistics 2030 Innovation Programme*, proposing strengthening the construction of "future-oriented and flexible and scalable" digital logistics infrastructure, data processing and platform solutions, and digital supply chains. Focusing on last-mile logistics solutions, they promoted the development of related technologies, such as pilot projects for remote-controlled delivery robots on open roads, to ensure that spatial planning and land-use planning tools can be adapted to the needs of the last-mile delivery. The *Program* is also designed to ensure that the federal states and local authorities implement related innovative pilot programs, such as the use of local public transport, night logistics or underground pipelines to transport goods.





1.3 Smart last-mile logistics solutions overview and challenges

At present, the main constructors and operators of smart last-mile logistics have actively developed and innovated

diversified last-mile delivery solutions that spanned OOH delivery mode and to-door delivery mode as well as related technologies in response to the current scenarios in the market.

Specifically, such solutions and technologies include: smart PUDOs, locker banks, unmanned vehicles, and drones. (figure 5).

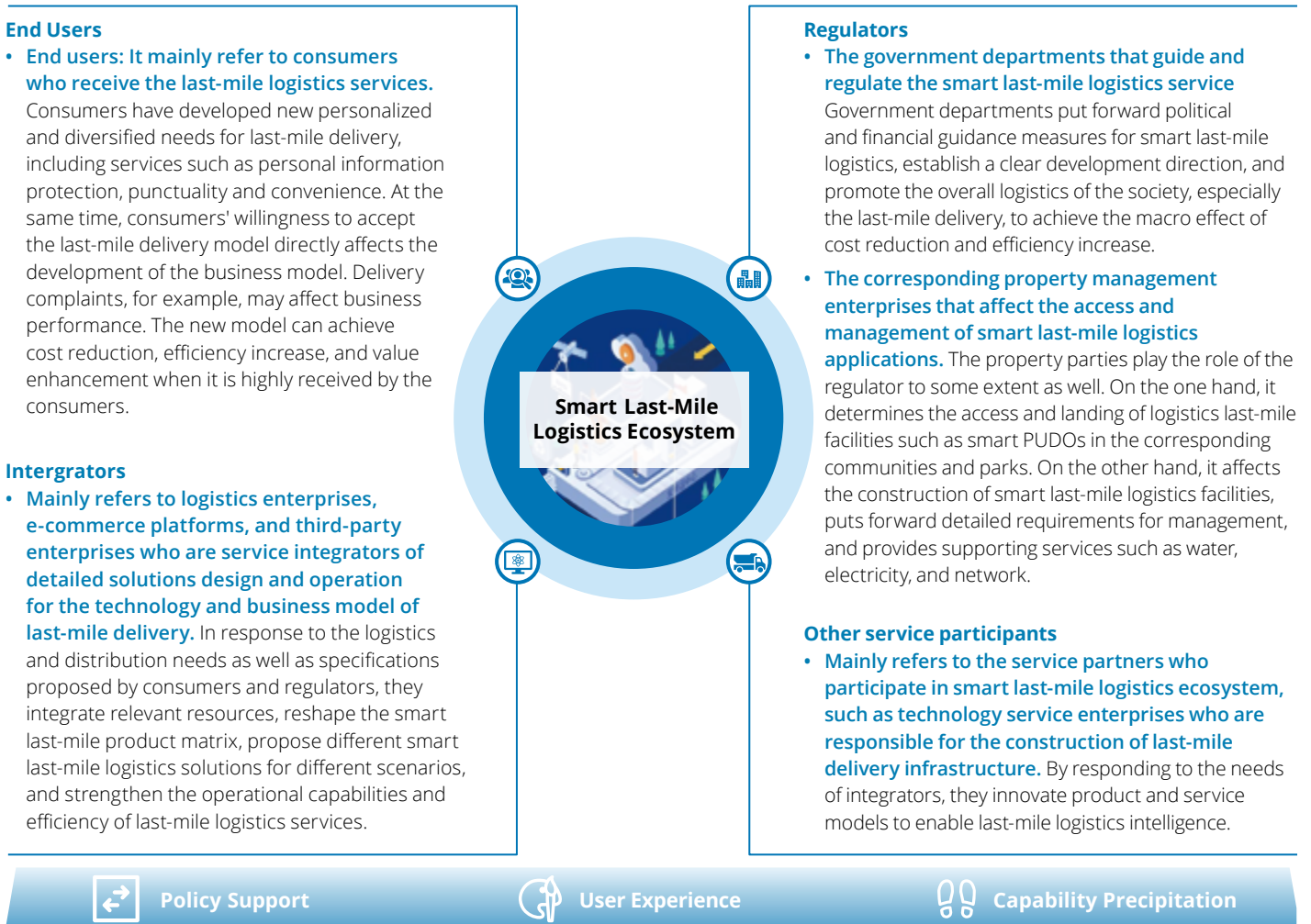
Figure 5: Last-mile Logistics delivery related smart solution

Solutions	Business models and challenges	
Smart PUDO		<p>Smart PUDO: PUDO is a delivery mode with a relatively high proportion and market share in the OOH delivery mode, and Smart PUDO is equipped with completed and mature, intelligent solutions. How to conduct intelligent transformation, upgrading existing PUDOs, and improving efficiency and profits will become challenging for Smart PUDOs.</p>
Smart Locker Bank		<p>Smart locker bank: E-commerce platforms, logistics companies and third-party technology service companies in the industry are currently highly optimistic about the development prospects of locker banks as smart last-mile logistics solutions. The challenge for some markets, such as China, is to have clearer business models.</p>
Unmanned Vehicle		<p>Unmanned vehicle: Unmanned vehicles are expected to achieve obvious efficiency improvement. The current e-commerce platforms and logistics companies in the industry, including Cainiao and other leading enterprises, have begun using unmanned vehicle technology to improve last-mile delivery capabilities, overall distribution efficiency, and service quality. However, in the future, it will mainly face development limitations in terms of technology and cost, restrictions from regulations and the dilemma of encountering the inability to get into the household.</p>
Drone		<p>Drone: As a highly intelligent solution, drones are expected to be used for "urgent delivery" in urban and remote rural areas to achieve a more obvious delivery time, improving performance. However, this intelligent device's future mainly faces safety and cost challenges. Meanwhile, obtaining a safe flight license in urban airspace for drones as general aviation is important. There will be more key pilots to face various ecological and regulatory challenges.</p>

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- **Drone:** As a highly intelligent solution, drones are expected to be used for "urgent delivery" in urban and remote rural areas to achieve a more obvious delivery time, improving performance. Amazon, JD, SF and other leading enterprises have begun to try using drone technology to improve last-mile delivery capabilities, including solving the distribution problems in rural and remote areas. However, this intelligent device's future mainly faces safety and cost challenges. Meanwhile, obtaining a safe flight license in urban airspace for drones as general aviation is important. There will be more key pilots to face various ecological and regulatory challenges.

1.4 Smart last-mile logistics ecosystem

Figure 6: Smart last-mile logistics related smart solution



The main stakeholders of the smart last-mile logistics ecosystem (Figure 6) can be divided into four groups as follows:

- **End users:** It mainly refers to consumers who receive the last-mile logistics services. Consumers have developed new personalized and diversified needs for last-mile

delivery, including services such as personal information protection, punctuality and convenience. At the same time, consumers' willingness to accept the last-mile delivery model directly affects the development of the business model. Delivery complaints, for example, may affect business performance. The new model can achieve cost

reduction, efficiency increase, and value enhancement when it is highly received by the consumers.

- **Regulators:** These mainly refer to the government departments that guide and regulate the smart last-mile logistics service and the corresponding property management enterprises that affect

the access and management of smart last-mile logistics applications. Government departments put forward political and financial guidance measures for smart last-mile logistics, establish a clear development direction, and promote the overall logistics of the society, especially the last-mile delivery, to achieve the macro effect of cost reduction and efficiency increase. The property parties play the role of the regulator to some extent as well. On the one hand, it determines the access and landing of logistics last-mile facilities such as smart PUDOs in the corresponding communities and parks. On the other hand, it affects the construction of smart last-mile logistics facilities, puts forward detailed requirements for management, and provides supporting services such as water, electricity, and network.

- **Integrators of smart last-mile logistics service:** It mainly refers to logistics enterprises,

e-commerce platforms, and third-party enterprises who are service integrators of detailed solutions design and operation for the technology and business model of last-mile delivery. In response to the logistics and distribution needs as well as specifications proposed by consumers and regulators, they integrate relevant resources, reshape the smart last-mile product matrix, propose different smart last-mile logistics solutions for different scenarios, and strengthen the operational capabilities and efficiency of last-mile logistics services.

- **Other service participants:** It mainly refers to the service partners who participate in smart last-mile logistics ecosystem, such as technology service enterprises who are responsible for the construction of last-mile delivery infrastructure. By responding to the needs of integrators, they innovate product and service models to enable last-mile logistics intelligence.

2. Global smart last-mile logistics market analysis

start
plan
idea

2.1 Smart last-mile logistics market assessment model

Core purpose: To identify development opportunities for smart last-mile delivery in different markets around the world, we applied a funnel model (Figure 7), which is based on a range of sub-dimensional indicators of market attractiveness and market maturity, and data analysis to identify target country markets with large opportunities from a long list of smart last-mile logistics markets.

Longlisted target markets: Europe (Belgium, Bulgaria, Denmark, Estonia, Finland, France, Germany, Great Britain, Italy, Netherlands, Poland, Romania, Spain, Sweden), Asia (China, Indonesia, Japan, Malaysia, Singapore, Vietnam), Americas (Brazil, USA).

Rationale of funnel evaluation model: We collect a series of sub-dimension information and data, such as market attractiveness and market maturity of each target markets through multiple data sources including Deloitte and Cainiao's business database, desk research, customer questionnaire survey feedback and database scanning. The collected information and data are subject to pre-processing and standardization processing. Then, we combine the weights of each sub-dimension for weighted accounting, which will render two major composite scores for each market in terms of market attractiveness and market maturity. Finally, we classify the target markets based on their total score.

Reference indicators: market attractiveness/market maturity

Market attractiveness:

- **Dimension:** Measuring the objective conditions of development attractiveness of target markets in terms of the political, economic, social-cultural and technological attraction surrounding smart last-mile logistics application.

• Evaluation perspectives (and reference indicators) include:

- **Political perspective:** Degree of policy support
- **Economic perspective:** National economic situation (GDP per capita), macroeconomic (retail market size), penetration of e-commerce (ratio of total e-commerce to total retail sales), logistics market scale (number of parcels delivered at the last mile)
- **Social-cultural perspective:** Infrastructure (infrastructure investment as a share of GDP), logistics development level (postal development composite index), density of logistics consumers (population density), self-pickup preference (consumers' preference on OOH delivery mode)
- **Technological perspective:** Level of technology (national technology capability rankings)

Market maturity:

- **Dimension:** Measure the objective conditions of development maturity of target markets in

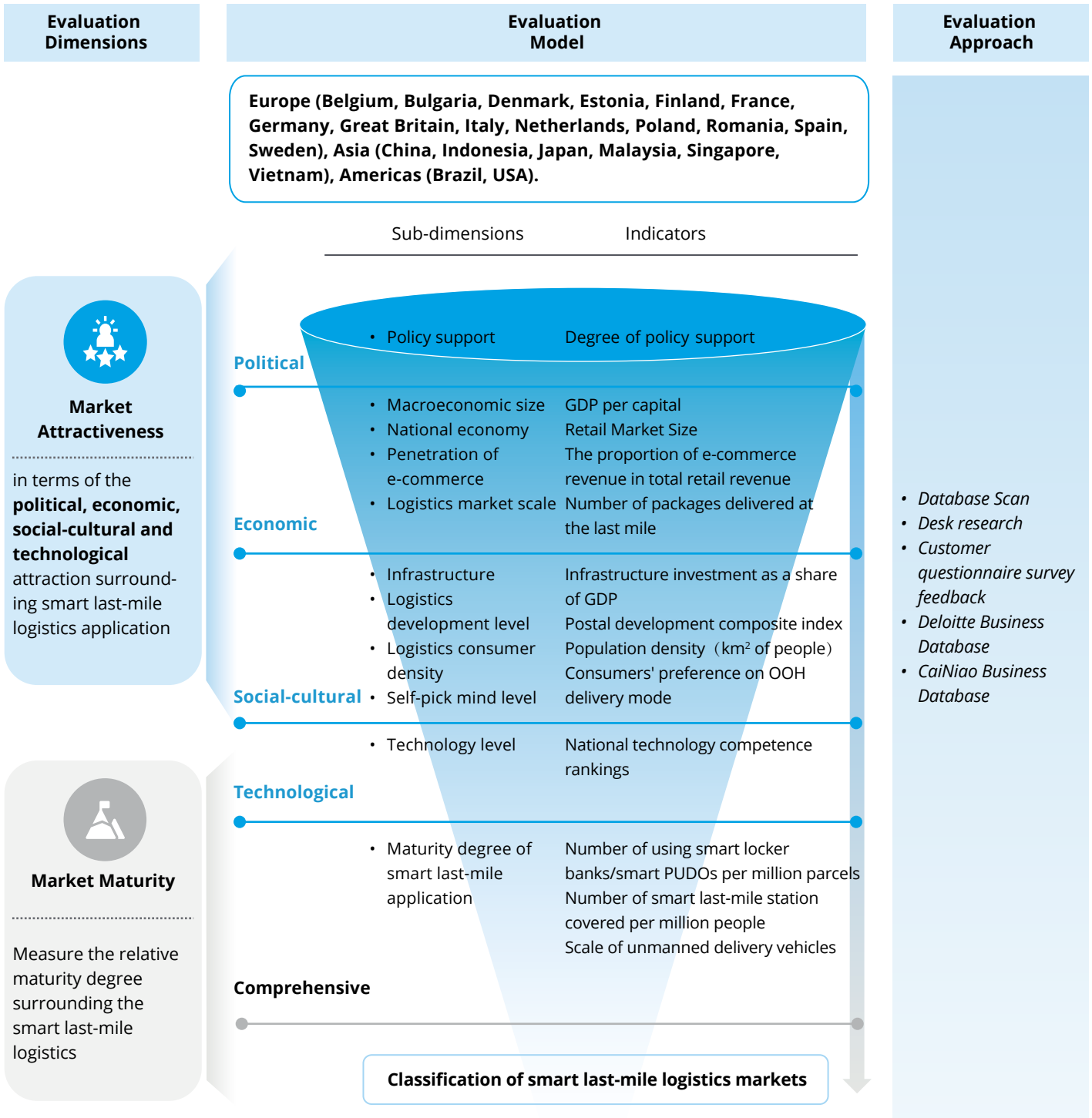
terms of economic, social-cultural, and technological developments surrounding the smart last-mile logistics application.

• Evaluation perspectives (and reference data indicators)

- Maturity degree of smart last-mile delivery application: Number of using smart locker banks/ smart PUDOs per million parcels, number of smart last-mile stations covered per million people, scale of unmanned delivery vehicles.



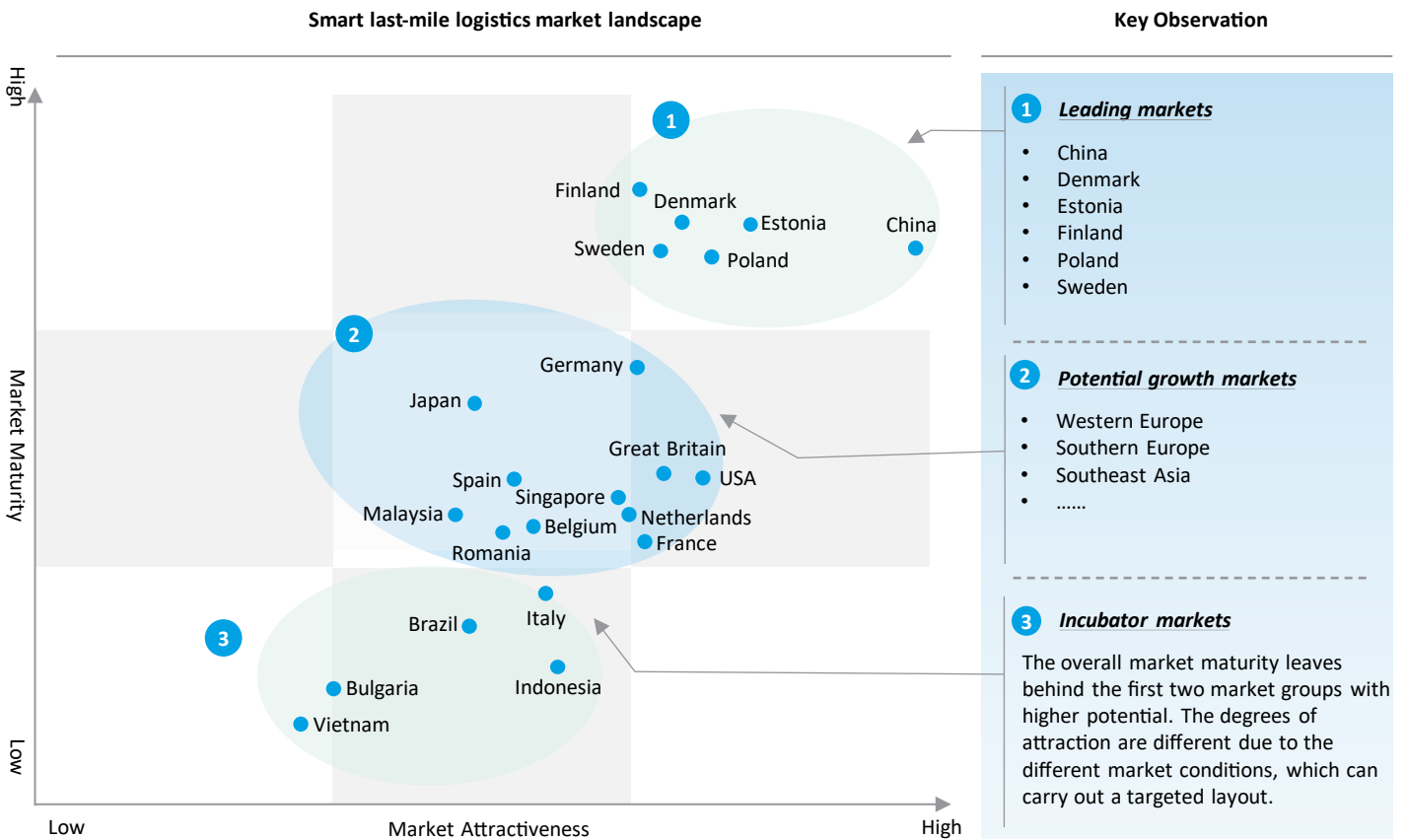
Figure 7: Smart last-mile logistics market assessment model



Source: Deloitte analysis, Cainiao Research Center

2.2 Smart last-mile logistics market landscape analysis

Figure 8: Smart last-mile logistics market landscape



Source: Deloitte analysis, Cainiao Research Center

Core purpose: After applying the analytical model, we will carry out a two-dimensional analysis and segmentation for each longlisted market based on indicator performance, and determine their corresponding entry approaches and intensity for the different market groups (Figure 8), and the classification of smart last-mile logistics markets.

Segmentation logic: Based on the market maturity and market attractiveness of each target market, a 3x3 axis chart is drawn, and the coordinates of each market are proportionally matched to the axis chart divided into nine quadrants, and finally each target country is in different quadrants of the axis chart, and be grouped into categories with differentiation. Higher market maturity

is considered to have more mature and sufficient competition; higher market attractiveness is considered to have more attractive market conditions, and vice versa.

Segmentation of market group result:

- **Key benchmark markets:** Countries such as China, Denmark, Estonia,

Finland, Poland, and Sweden are attractive and mature. For example, China has a large logistics market, high infrastructure level, high e-commerce penetration rate and the highest market attraction. The key benchmark market countries have a high level of technology application. Smart last-mile logistics application, represented by smart locker banks, has a high layout density and market maturity. Key benchmark markets' technologies or business models can be used for reference in other markets.

- **Potential growth markets:**
Countries in such as Western Europe, Southern Europe, Southeast

Asia and other countries have moderate market maturity and across the markets with high development attractiveness of objective conditions in the smart last-mile logistics application; In the future, this market group has great development potential, especially for the market with large maturity improvement space, which should be arranged as soon as possible.

- **Sub-potential incubator markets:**
The overall market maturity leaves behind the first two market groups with higher potential. The degrees of attraction are different due to the different market conditions, which can carry out a targeted layout.



2.3 Analysis of representative country and its smart last-mile solutions

2.3.1 China

Background Introduction

China is a typical market that actively embraces technology. After issuing the details of the "14th Five-Year Plan" in March 2021, the Chinese government issued the "14th Five-Year Plan for the Development of the Digital Economy" in January 2022, specifically setting out the requirements and objectives for the development of the digital economy and clarifying that the development of the digital economy is a strategic choice to seize the opportunities of the new round of technological revolution and industrial change. Smart last-mile logistics enjoys a good environment

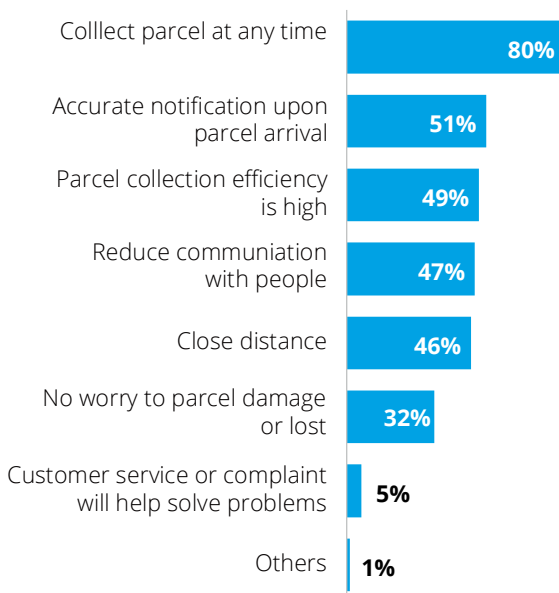
for development in China, and it has also seized the trend of the times with significant progress achieved, such as smart locker banks, smart PUDOs, unmanned vehicles and drones. The speed and scale of its development have made remarkable progress.

In addition, China's economic and social environment has also provided a solid foundation for the development of smart last-mile logistics. Overall, the attractiveness of smart last-mile logistics in the Chinese market is high (Figure 9). China's total retail sales of consumer goods were about CNY 44 trillion in 2022, the e-commerce penetration rate was about 28.5%, and the number of parcels exceeded one hundred billion. Infrastructure is well developed. All the above are ranked among the top in the world.

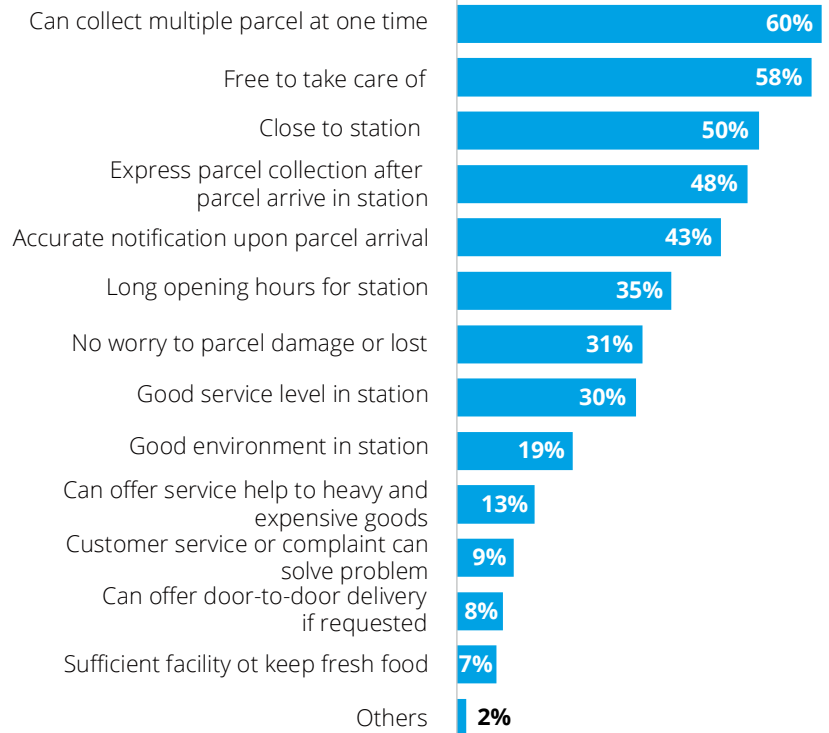
At the same time, Chinese consumers also have a relatively high acceptance rate of picking up goods through smart locker banks and smart PUDOs, especially in first-tier urban areas with high residential density. OOH devices, such as locker banks, which can provide 24/7 convenience, are an important service delivery method for white-collar workers who leave work late. According to research data provided by Cainiao's users and business research team, the main reasons why consumers are willing to use smart locker banks and smart PUDOs include the ability to pick up parcels at any time, the ability to pick up multiple parcels at one time, free storage, timely and accurate notification of arrival, and high pick-up efficiency.

Figure 9: Research on the reasons why users choose OOH

What users like most about locker banks



What users like most about smart PUDOs

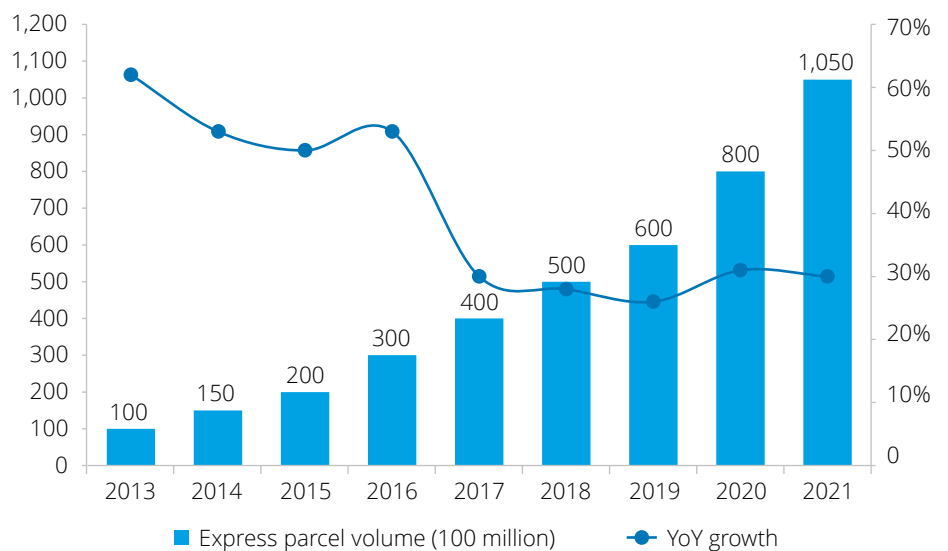


Data source: Cainiao's users and business research

Credit to the widespread use of smart last-mile logistics applications in China, last-mile delivery in China supports many parcels. According to public data, China's express parcel volume reached 108 billion in 2021, with a 30% yearly increase, accounting for more than

half of global parcels. The number of parcels per capita in China is 1.7 times higher than the number of parcels per capita globally. Smart experience in the last mile has helped China to better address the pressures and challenges of last-mile delivery.

Figure 10: 2013-2021 Chinese Express Parcel market size and growth rate (100 million, %)



Source: Deloitte analysis, Cainiao Research Center

Market analysis

This report was developed from several dimensions of the sub-markets with a high degree of intelligence in the smart last-mile logistics – smart PUDOs, locker banks, unmanned vehicles, and drones. China's smart last-mile logistics market has experienced relatively rapid growth in all segments compared to other countries.

The major market players in China's smart last-mile logistics are divided into the following categories.

They are E-commerce platform companies, logistics companies, and third-party enterprises, with each having different interest-driven objectives. The e-commerce platform companies aim to improve customer experience, increase customer stickiness, improve delivery efficiency, and reduce total costs. The logistics companies hope to strengthen the control ability of the last-mile delivery and enrich the delivery business model. Compared to the first two, third-party enterprises are more focused on capturing the market and making profits in a niche area.

Figure 11

Smart last-mile logistics	Market Player		
	E-commerce platform	Logistics companies	Third-party enterprises
Smart PUDOs	Duoduo Stations	Cainiao, ZTO Tuxi Express Supermarket, YTO Mama Stations, Yunda Express Supermarket, SF Express sending and receiving, etc.	Kuaibao Stations
Smart pick-up lockers	JD	Cainiao, SF's Hive Box, EMS locker, ZTO	Jiangsu Cloud Locker, RRS.com, etc.
Unmanned vehicles	JD	Cainiao, ZTO, Deppon	Hsin Shen Intelligent, White Rhino, Yi Qing Innovation, New Stoneware, Smart Walker, etc.
Drones	JD	SF	Swift Ant Technology, EVA, Smart Air, etc.
Target	Improve customer experience, increase customer stickiness, and improve distribution efficiency and reduce costs	Strengthen the control capacity at the end of distribution, and enrich the delivery business model	Third party companies are more focused on capturing market share and profitability in niche areas than the first two entities

Source: Deloitte analysis, Cainiao Research Center

From the perspective of market segments, most of them are franchises in the smart PUDO market, such as Duoduo PUDO, logistics companies including Cainiao, ZTO, YTO, Yunda, SF, and third-party enterprises such as Kuaibao PUDO.

In the locker bank market, SF's Hive Box has taken the highest share. After Hive Box acquired China Post Smart Delivery in May 2020, Hive Box's market share reached nearly 70%, making it the absolute leading player.

The main players in the unmanned vehicle delivery market, especially in outdoor scenes, are the e-commerce platform JD.com, logistics companies such as Cainiao, ZTO and Deppon, along with other third-party companies. The overall market is still in its initial development stage. Cainiao's "Xiaomanlv" unmanned delivery vehicle, for example, has now increased the number to 700, providing schedule and to-door delivery services to 400 universities across China. As of "double 11" of 2022,

the "Xiaomanlv" has delivered more than 20 million orders, breaking the last-mile unmanned delivery record in China.

In the drone delivery market, the US is leading the way across the globe, Europe is following closely, and China is catching up. Currently, the main Chinese players are JD, SF, and a host of startups. Other logistics service providers, such as China Post, Cainiao, ZTO, YTO and Deppon, have also experimented with drones.

Figure 12

Smart Last-mile logistics solution	Sources of Revenue
Smart PUDO	<ul style="list-style-type: none"> • Technical service fees • Advertising fee • Community services, community commerce
Smart Locker Banks	<ul style="list-style-type: none"> • Package pick-up and drop-off service fees • Advertising fee • Others: Community O2O business entrance, etc.
Unmanned vehicle	<ul style="list-style-type: none"> • Service fees • Others: e.g. advertising fees
Drone	<ul style="list-style-type: none"> • Service fees • Others: e.g. advertising fees

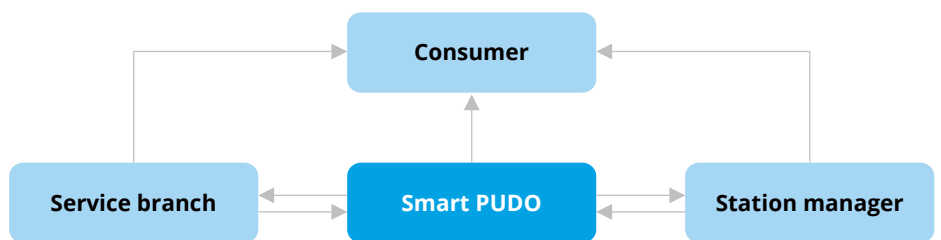
Source: Deloitte analysis, Cainiao Research Center

From the perspective of revenue sources, in the smart PUDO market, the revenue of franchised sites mainly come from technical service fees, advertising fees, community services and community commerce such as group purchases.

As shown in Figure 13, smart PUDOs, in collaboration with service branches and managers, serve consumers, meet consumer demand for self-pickup, handle business problems,

and provide to-door delivery and other services. Among them, service branches refer to branches of express companies; station managers play the role of internal customers in the franchise system and as employees in the self-operated system. Usually, the smart PUDO market players charge technical service fees to the station manager. If the couriers put parcels in the station, he pays the station manager for settlement.

Figure 13



Source: Deloitte analysis, Cainiao Research Center

The business revenue sources of smart locker banks include parcel collection and delivery, advertising, and community O2O business. Fees are collected from couriers, logistics companies and, in some scenarios, consumers. The profitability of smart locker banks is low in China, and even Hive Box is still having trouble turning a profit. However, due to fierce competition in the express delivery industry, express companies are relying on lower delivery fees to reduce costs, leading to an increasing workload of couriers. Couriers themselves are reluctant to give up the use of lockers due to a shortage of couriers. From a comprehensive perspective, major logistics service providers cannot easily give up lockers.

Unmanned delivery, including unmanned vehicles and drones, is still in the exploration stage in China, and there is still a certain distance from the scale of commercialization. Drones also have certain restrictions at the policy level, and the usage scenarios are limited. The profit model needs to be further explored.

Summary

Overall, smart last-mile logistics in the Chinese market have improved the efficiency of last-mile delivery. The strengths and advancements of China's smart last-mile logistics are reflected in the intelligence of all elements and the process. The application of digital technology in China also has a benchmarking

effect on a global scale. Intelligent last-mile logistics involves digitizing all elements, including personnel, parcels, equipment, vehicles, etc. For example, in a smart PUDO with a high level of intelligence, parcel automation can be realized through the smart label during the stock-in process, so the parcels are quickly located and confirmed at the operation node. Meanwhile, abnormal situations can be identified through monitoring equipment with edge computing capabilities. The digitization of the whole process is shown in core links such as warehousing, monitoring, self-pickup, and unmanned vehicle delivery.

However, due to the business model of e-commerce parcels and the historical mind formation of the to-door service, the profitability of the self-pickup business in China is challenging, especially for locker banks. However, even so, from a logistics service provider's perspective, it can reduce overall labor costs, improve last-mile delivery efficiency, and provide consumers with more choices. For e-commerce platforms, it can also develop advantages in terms of cost, user experience and network coverage.

In addition, digital technology can better meet the requirements of industry norms and social development. For example, during the pandemic, gathering people may bring more possibility of infection. With the unmanned operation, people's contact

can be reduced so that customers can feel more assured when sending and receiving parcels, which may help prevent pandemic transmission at the social level.

The experience of smart last-mile logistics technology applications in the Chinese market is also a good practice for other countries. Each market needs to consider its market characteristics, consumer mindset and other factors to better apply technology to business scenarios and help local markets provide the best last-mile logistics and delivery solutions.

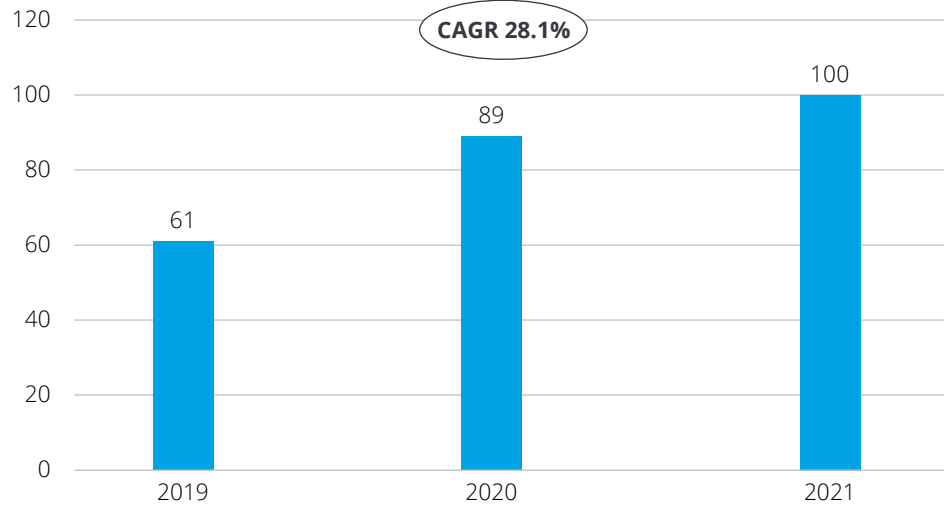
2.3.2 Poland

Background Introduction

Located in Central Europe, Poland has a long history and is the sixth-largest economy in the European Union, with Warsaw as its capital and largest city. Poland covers a land area of 312,697 square kilometers, has a population of approximately 38.26 million with a population density of 124 inhabitants per square kilometer.

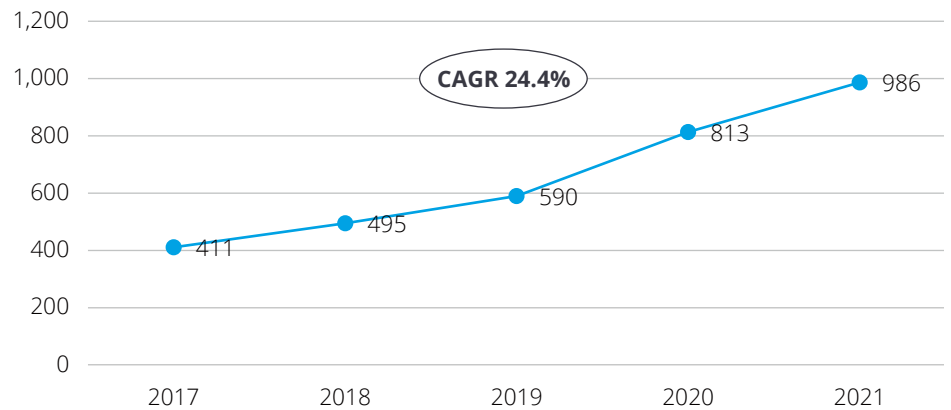
In 2021, the e-commerce retail sales in Poland exceeded PLN 100bn, with a CAGR of 28.1% since 2019. (figure 14) This is one of the key reasons for rapid OOH development in Poland. The Polish parcel volume grew 21%, year over year, reaching 986 million in 2021 – up from 813 million in 2020. (figure 15)

Figure 14: E-commerce retail sales in Poland (in billion PLN)



Source: Deloitte analysis, Cainiao Research Center

Figure 15: 2017-2021 Poland CEP Market in volume(million parcels)

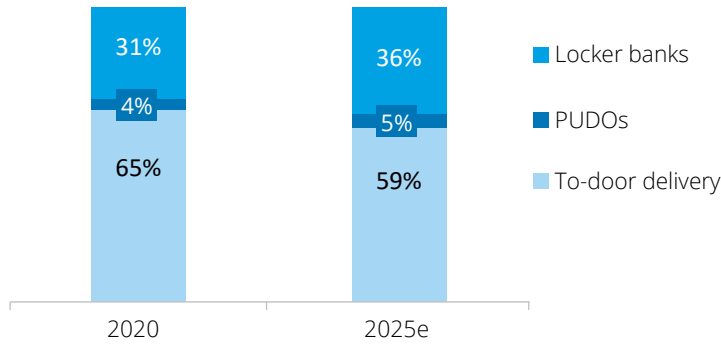


Source: Deloitte analysis, Cainiao Research Center

In addition to this, consumers in Poland have a higher willingness in accepting self-pickup options than in other European countries, especially lockers, which will account for around

31% of the Polish market in 2020 and are expected to be 36% by 2025, significantly higher than in other European countries.

Figure 16: The proportion of each last-mile delivery mode in Poland

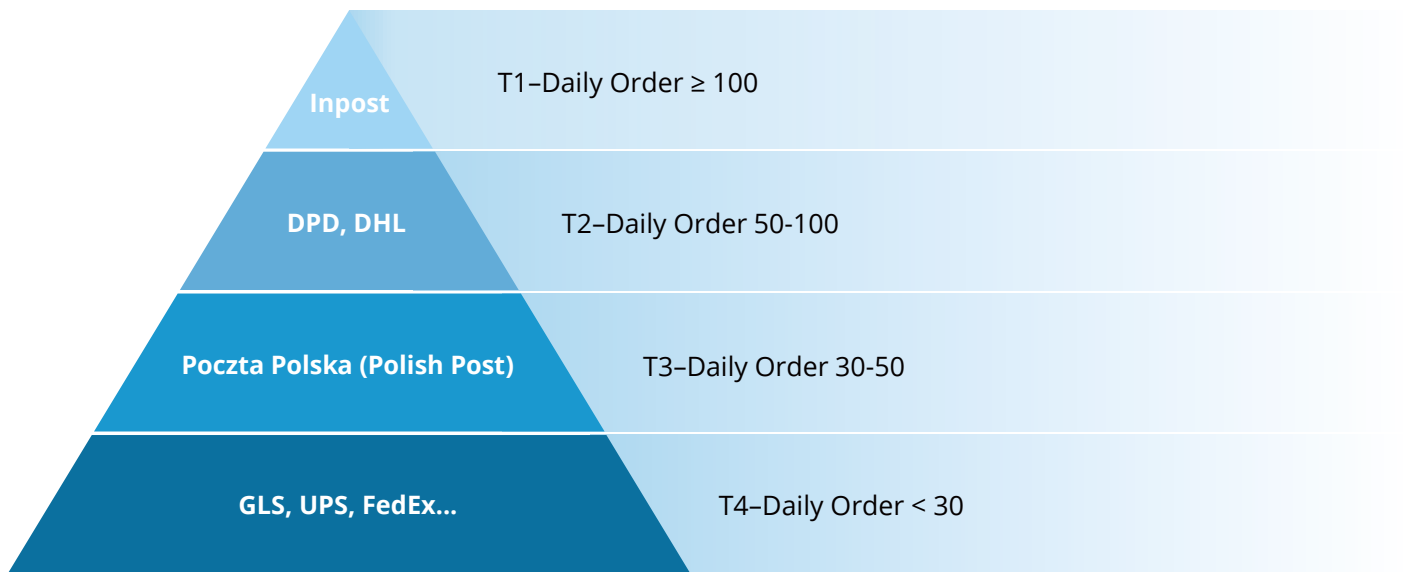


Source: Deloitte analysis, Cainiao Research Center

i Market analysis

Poland is one of the fastest expanding markets for OOH networks in Europe, with 80% growth in 2021 from 2020, and in 2021 the locker bank volume in Poland exceeded 20,000, making it the largest locker bank market in Europe. The entire CEP market has a high concentration rate, with 85% of the order volume concentrated in the top 4 couriers: Inpost, DPD, DHL, and Poczta Polska (Polish Post). Inpost, as the leader of the CEP market, is firmly staying in the first tier, and more than 80% of its business is OOH.

Figure 17: Top 4 players' daily order volume in 2022 Polish CEP market , (unit: 10 thousand orders)



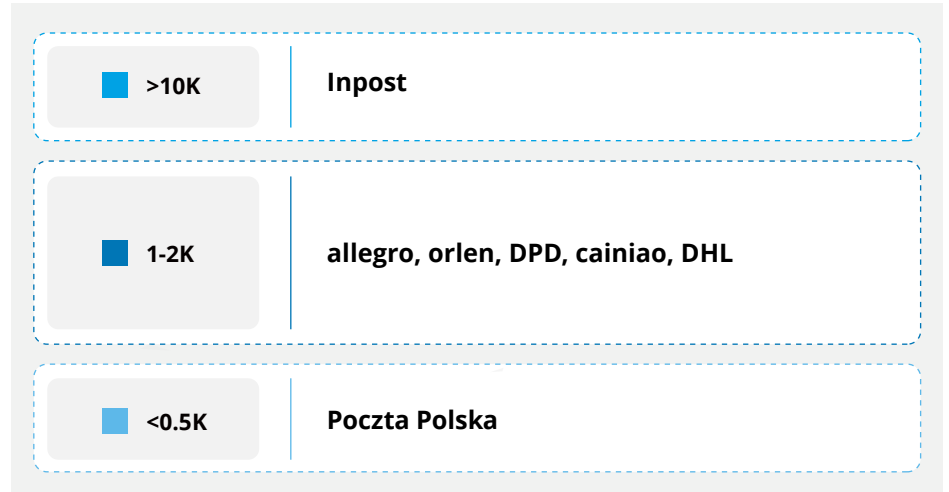
Source: Deloitte analysis, Cainiao Research Center

Poland is now seen as a best practice for locker banks in Europe. And InPost has the largest number of locker banks among Polish top logistics players, with a total of over 16,000 locker banks in 2022. DHL, DPD and Poczta Polska have also put a certain scale of locker

banks to support the development of their OOH business.

In addition to the above leading logistics players, e-commerce platforms, other domestic and foreign logistics companies, energy

companies, etc., have also joined to build their capabilities in the locker bank network; for example, Allegro (a Polish e-commerce giant), Cainiao from Alibaba, PKN Orlen (a petrochemical company), etc.

Figure 18: Locker bank Volume of Key Players in Polish Market

Source: Deloitte analysis, Cainiao Research Center

In the Polish market, the solutions of smart locker banks are also relatively more mature and solid. For example, the smart locker banks of the Cainiao-DHL cooperation project ("Cooperation Project") are more suitable for the Polish market. While Cainiao's locker banks in China are mainly for dropping off and picking up items, those in Poland are more functional, such as cash-on-delivery (COD) function through POS machines, parcel sending function, and more consumer-centric life scenarios at a later stage, for example, magazine and newspaper delivery. Not only that, but the details are also more adapted to the characteristics of this market – the locker compartment design is more optimized to adapt to the rainy and snowy weather in Poland; the doors of locker compartments support re-opening to help solve the problem of accidental close; during the drop-off process, if the locker

compartment size is wrong to fit in, it supports the change of another locker compartment; and the mobile app is also able to support remote control on locker compartments' opening, closing, and locking in advance, etc.

Summary

Poland is a market where consumers' self-pickup preference is very strong, especially for locker banks, so we also see a fast growth rate of smart locker banks in this market. Behind this is the power of technology overlaid with a smoothly functioning profitability model, which is ultimately reflected in the profitability of the top players.

It is worth noting that when comparing the smart locker bank market in China with that in Poland, we find that Hive Box, also an absolute leader, is not as profitable as Inpost in Poland. According to the financial report, Hive Box lost CNY 781 million in 2019

and CNY 846 million in the first three quarters of 2020. Inpost's net profit for 2020 is PLN 350 million (USD 73 million); for 2021, it is PLN 461 million (USD 96 million).

The reasons for this may be related to the characteristics of the market, in particular, the consumer mindset. As Polish consumers are more receptive to choosing locker banks as a cheaper

delivery method during payment, this provides the basis for Polish players' profitability. But Chinese consumers have a stronger mindset of free delivery, a weaker mindset for paying for service, and are more receptive to door-to-door delivery. So, it is difficult for locker bank service providers to charge. The table below reflects the differences between the two types of countries.

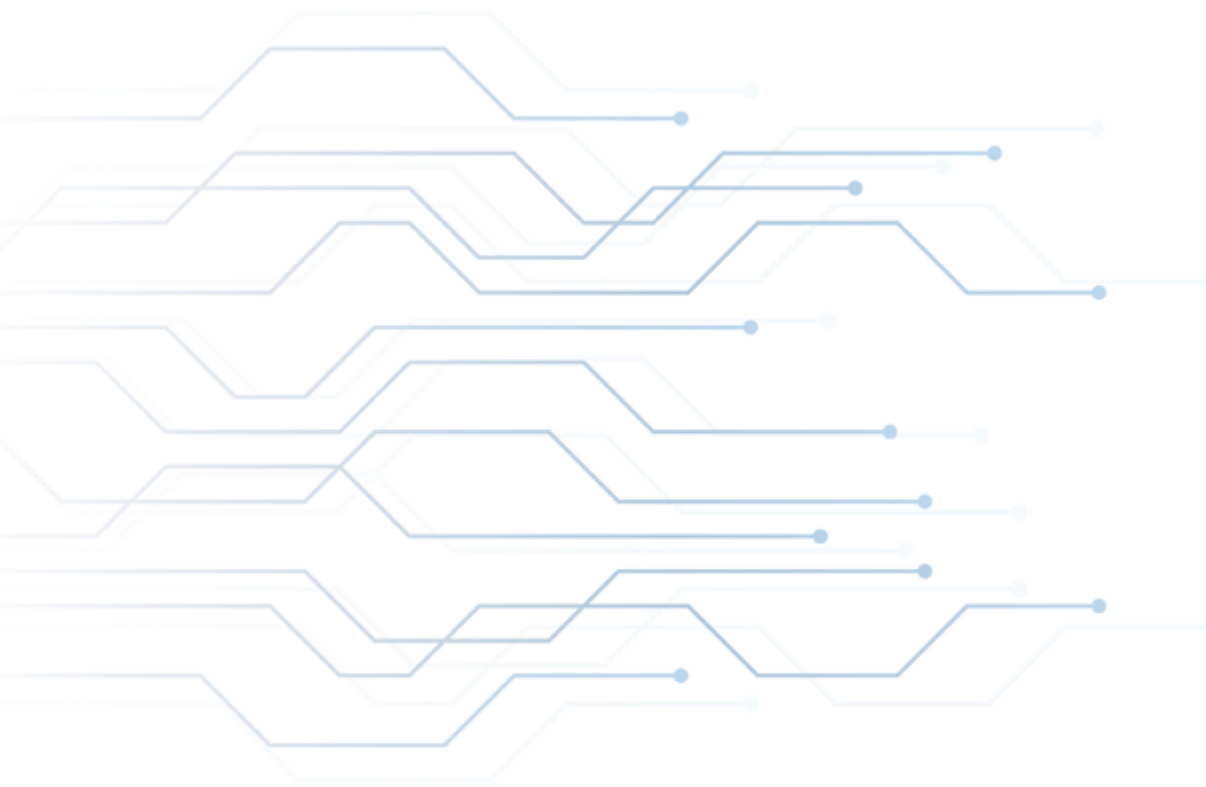


Figure 19: Locker bank business model comparison in different markets

Representative market	Market Characteristics	The role of locker owner	Representative company	Charging object	Charging pattern
Poland	Higher profit margins: due to labor costs increase, door-to-door delivery fees are generally 20-40% higher than locker bank delivery fee, and under higher network coverage, consumers are more motivated to choose locker banks.	Main e-commerce platforms	Allegro (own Allegro One Box)	Consumers	When selling goods on the e-commerce platform, it comes with a smart locker bank selection. (Allegro is promoting its own locker Allegro, and has a certain price subsidy advantage)
		Logistic enterprises	InPost, DHL	E-commerce platforms	For example, Allegro uses InPost logistics services, including last mile smart lockers, and pays for them
				Other logistics providers	Other logistics providers use last mile smart lockers and pay by the order
China	Lower profit margins: Chinese consumers have a stronger mindset of free delivery, a weaker mindset for paying for service, and are more receptive to door-to-door delivery. They default free delivery and prefer door-to-door service without payment, unless there is a time requirement. So it is difficult for service providers to charge.	Main e-commerce platforms	JD; Taobao/Tmall + Cainiao	Consumers/ Merchants	For self-operated business, smart lockers are part of the delivery service and are included in the consumer's payment For platform vendors, smart lockers are paid by merchants as delivery services, which are essentially still paid by consumers
		Logistic enterprises	Hive Box	Couriers	Due to the heavy workload, couriers are willing to pay for pick-up lockers
				Consumers	Delayed pickup; personal parcel sending, etc
				Others	Such as advertising, community O2O scenes, etc

Source: Deloitte analysis, Cainiao Research Center

2.3.3 Singapore

Background Introduction

Singapore is a city-states island nation located in Southeast Asia. After its independence in 1965, Singapore quickly transformed itself into one of Asia's Four Little Dragons, relying on the operation of international trade and human capital and becoming one of Asia's important major financial, service and shipping centers thanks to its geographical advantage.

With a land area of 728 square kilometers and a population of 5.686 million in 2020, Singapore has the third highest population density in the world at 7,810 people per square kilometer. Despite its small size and limited resources, Singapore has a

well-developed economy and its GDP per capita will be USD 72,795 in 2021, ranking 5th in the world according to the IMF. Singapore also has a relatively high level of infrastructure development, ranking 10th in the world and 1st in the Asia Pacific according to the UPU's 2IPD Global Postal Development Comparative Index, demonstrating the country's overall high level of postal development. Singapore is also technologically advanced, ranking 5th in the world in the 2021 Technology and Innovation Report released by the United Nations.

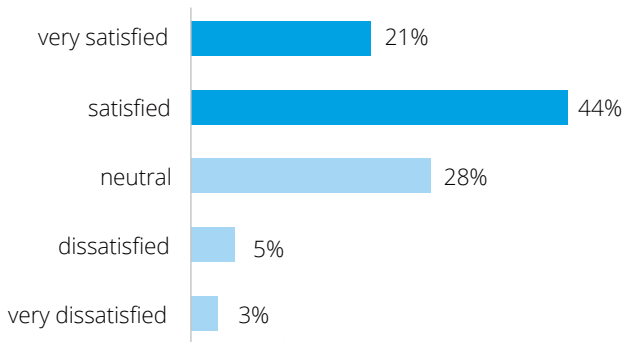
In 2021, the retail market in Singapore will be approximately US\$24,941.7 million, an increase of 12.5% compared to 2020. According to our calculations,

the number of parcels in Singapore is around 260 million a year, and the number of parcels per capita is around 46 per person, higher than the global average of 34 per person, which is a relatively high level in terms of market attractiveness. (Refer to Figure 7)

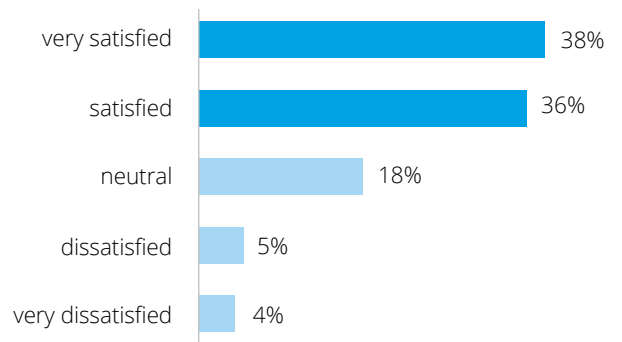
Consumers in Singapore have a certain self-pickup mind. According to research findings from the National University of Singapore in collaboration with IMDA, consumers are satisfied with locker bank services because they are more controllable (80%) and more private (70%). Consumers are 74% satisfied with locker banks, 38% are very satisfied, and 65% are satisfied with PUDOs, 21% are very satisfied.

Figure 20

Research: Satisfaction with the PUDOs



Research: Satisfaction with the locker banks



Research: Reasons to use locker banks (Locker Alliance)



Source: National University of Singapore and IMDA

i Market analysis

The Singapore market is unique in that, as a city-state of over five million people, it has become more influential internationally than many countries, with more than ten times its size.

The dominant players in Singapore's smart last-mile logistics market are state-owned enterprises, with market players including SingPost, IMDA's subsidiary Pick Network and Parcel Santa, etc. In the Singapore market, there are approximately 1,600 smart locker banks.

The locker bank market in Singapore has its pain points as well. According to our research, the usage rate of locker banks in Singapore is around 10%, compared to around 30-40% in China.

The reasons may be the following: 1) The overall convenience of the locker bank still needs to be improved. Singapore is near the equator and has a hotter climate, so to-door service is relatively more convenient. Convenience requires coverage, density and other factors that can enhance the consumer experience. 2) Price advantage is not obvious. Especially in the context of the generally high incomes in Singapore, there is no significant difference in price between locker banks and to-door delivery, and consumers are not very sensitive to the price of to-door delivery.

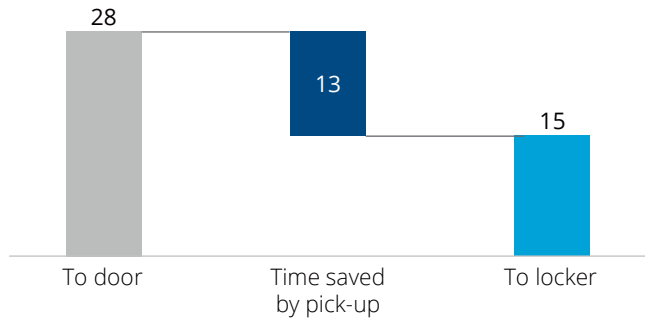
Therefore, the Singapore market needs to further enhance the convenience of using lockers for consumers and

expand the effective coverage to reduce consumers' concerns about using them. At the same time, there is a need to further demonstrate the price advantages. For example, promote consumers to accept locker banks and develop the habit of using them through subsidized offers.

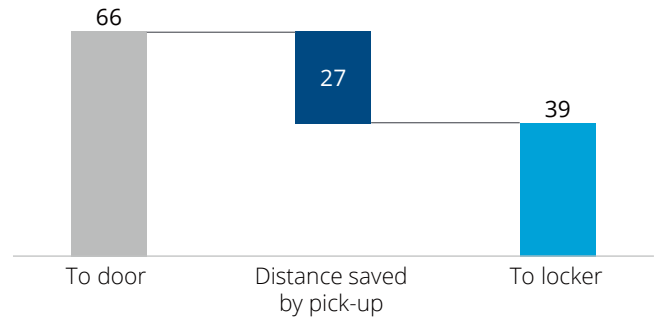
In addition to providing consumers with a wide range of choices, using locker banks is also a good way for logistics service providers to improve efficiency and reduce costs. According to a study conducted by the National University of Singapore in collaboration with IMDA, smart locker banks have improved delivery companies' efficiency and cost savings.

Figure 21

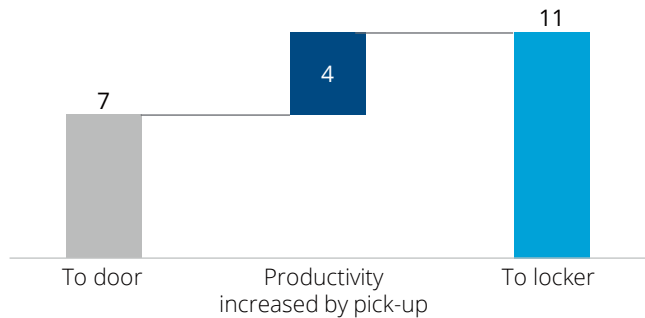
Manpower required to deliver 150 (hours)



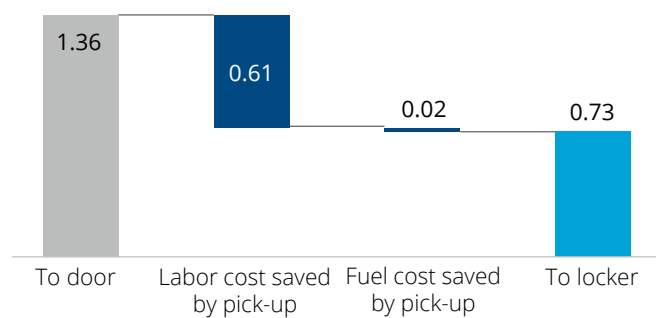
Distance for 150 parcels (km)



Number of parcels delivered per unit of labor force (pcs)



Delivery cost per parcel (SGD)



Source: National University of Singapore and IMDA

2 Summary

In Singapore, although smart locker banks are not currently a mainstream option in last-mile delivery, they are still growing with greater importance, and there may be several key reasons behind this:

- According to the Population Brief 2021 released by the Population and Talent Agency of Singapore, the proportion of non-CMP migrant workers (non-manufacturing, shipping, and processing workers) in Singapore's non-resident population, which is the classification of couriers, is only 5.13% of the total population, which is relatively small. The continuous shortage of related foreign workers and rising labor costs will increase the demand for low-cost and efficient last-mile delivery services.
- Singapore's economy is still developing rapidly, which will inevitably lead to an upward trend in parcel volume.
- Increased environmental protection awareness will lead to OOH services' increased popularity.

Therefore, in the future, using smart locker banks may be an effective way to improve last-mile logistics in the Singapore market.

3. Future-proof Smart last-mile solutions



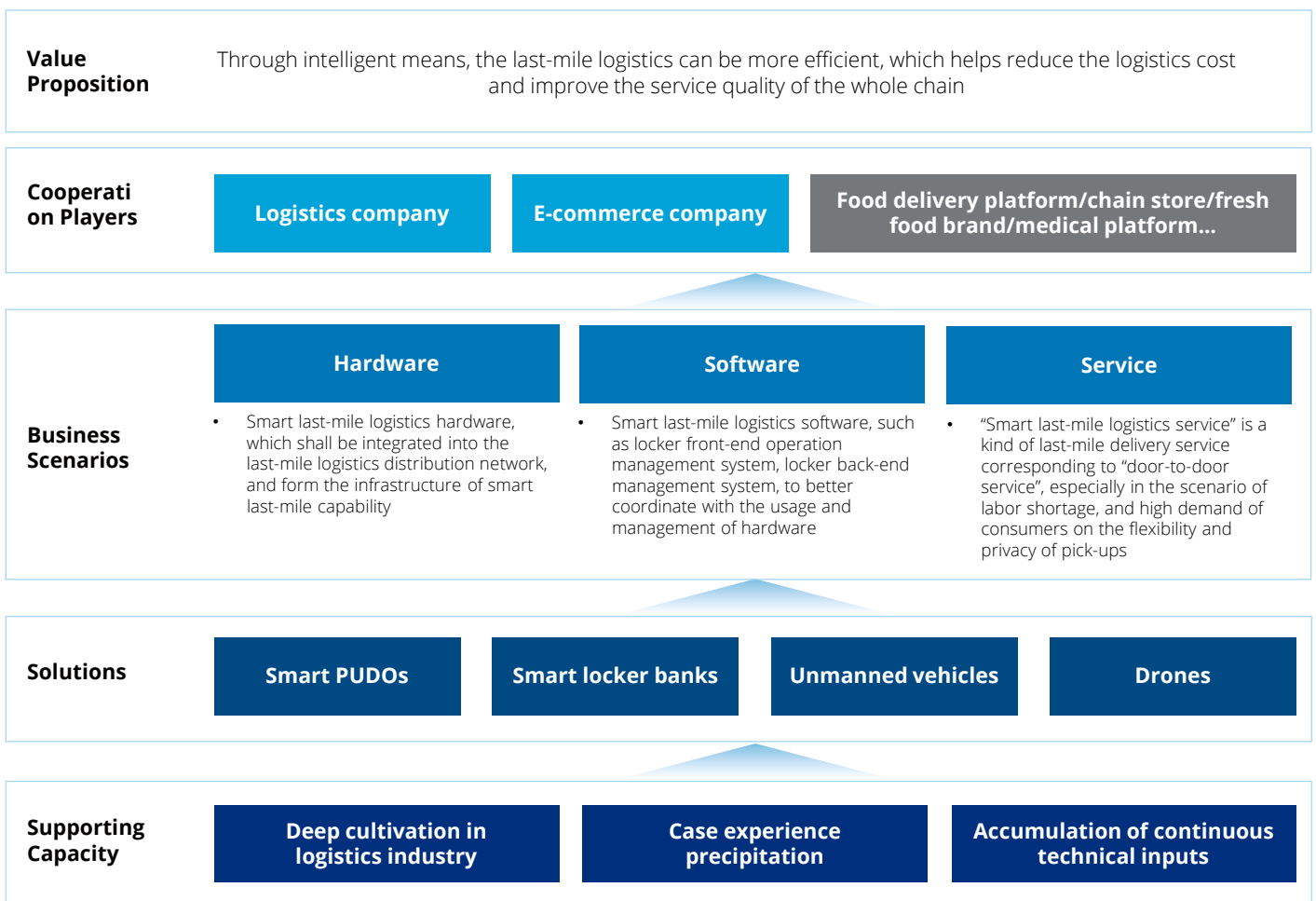
After identifying and analyzing the objective conditions and solutions of each target country with different development levels of smart last-mile delivery by category, we summarized the "Smart Last-mile

Logistics" methodology. With it, we clearly explained and deeply analyze the actual business scenarios, advantages and disadvantages, and application cases of each solution, so as to maximize the empowerment

of potential partners in different countries to make decisions and considerations on actual investment and operation of smart last-mile delivery solutions.

3.1 Smart last-mile logistics methodology

Figure 22: Smart last-mile logistics methodology



Source: Deloitte analysis, Cainiao Research Center

Facing the future, we have summarized the core methodology of "Smart Last-Mile Logistics" from the five directions of value proposition, cooperation players, business scenarios, solutions, and supporting capability, and expounded the key sections of "smart last-mile delivery" from our perspective. **At the solution level, elaborate on specific business scenarios, business models, components, strengths and weaknesses, and related cases.**

Value proposition: Through intelligent means, the last-mile logistics can be more efficient, which helps reduce the logistics cost and improve the service quality of the whole chain.

Cooperation players: Mainly, logistics companies and e-commerce platforms have the potential demand to improve last-mile delivery capability with smart last-mile logistics means. This report does not discuss others like food delivery platforms, chain stores, fresh food brands, and medical platforms.

Business Scenarios:

- Smart last-mile logistics hardware to be integrated into the last-mile delivery network and form the infrastructure of smart last-mile capability.
- Smart last-mile logistics software, such as locker front-end operation management system and locker back-end management system, to better coordinate hardware usage and management.
- "Smart last-mile logistics service" is a kind of last-mile delivery service corresponding to "to-door service", especially in the scenarios of labor

shortage and high demand of consumers on the flexibility and privacy of pick-ups.

Solutions

- **Smart PUDOs:** Improve the overall efficiency of the station business operation with the digital equipment in the station. Shorten the delivery time and improve the labor effectiveness of the station through the transformation of self-help stations. Combine innovative business to expand the revenue source of stations. Improve station security with AI and other means.
- **Smart locker banks:** By providing hardware and software of smart locker banks, including hardware, front-end operation management system, back-end management system, as well as smart locker bank services, it enriches the pick-up network, improves the last-mile delivery efficiency, reduces the overall delivery cost, and provides consumers with more choices.
- **Unmanned vehicles:** Using the latest AI and autonomous driving technology, unmanned vehicles provide last-mile delivery service for the last three kilometers, realizing the purpose of efficient intelligence, safety, and reliability and reducing the pressure of distribution manpower.
- **Drones:** Logistics drone is a solution directly oriented to last-mile delivery, which can easily pass through complex terrain and vertical space and provide distribution services in the last three kilometers to achieve point-to-point delivery to the full extent.

Supporting capabilities: The realization of the solutions for smart last-mile delivery needs the support of the underlying capabilities. The core underlying capabilities include the following:

- **Deep cultivation in the logistics industry:** Through years of precipitation and accumulation in the logistics industry, we have a deep understanding of the scenarios and the core demands of partners such as logistics companies and e-commerce platforms, understand the market situation, including consumer preferences, and provide appropriate solutions according to the characteristics of the industry.
- **Case experience precipitation:** With large amounts of "smart last-mile logistics" application cases and landing schemes, and continuous accumulation and iteration, we can provide better and faster solutions suitable for users, keep close to customer needs, reduce customer's opportunity costs of trial and error, quickly seize the market, acquire, and retain users, and improve the consumer experience.
- **Continuous technical inputs:** The scientific and technological investment of "smart last-mile delivery" continuously improves the intelligent level of solutions and polishes the technology to make them fit with scenarios more closely. It includes the improvement of hardware functions, the enhancement of software matching ability, the improvement of algorithm accuracy, the design of multiple security, and cost optimization.

3.2 The smart last-mile logistics solutions and related cases

3.2.1 Smart PUDOs

Smart PUDO is a solution for last-mile logistics that upgrades PUDOs and the supporting services through intelligent tools.

In the key smart business scenarios, the core is the self-service PUDO, where customers can pick up the parcels by themselves through smart equipment without the help of shop assistants to search for goods. It greatly releases manpower from the hard work of searching for goods and saves customers' waiting time. At the same time, it can also ensure the parcel's safety during the pick-up process. In some more advanced PUDOs, extending the night pick-up time with unmanned service is possible, providing customers with more flexibility and convenience. Its realization requires the application of self-service pick-up equipment and the escort of security monitoring.

Among the key components of the smart PUDO, the most important is inbound and outbound equipment. PUDOs with an average level of intelligence will complete the operation in and out of the warehouse through basic equipment such as mobile phones, while PUDOs with a higher level of intelligence will be superimposed with sheet printers,

PDAs, outbound scanners, and other equipment. The higher the level of intelligence, the less time customers will spend queuing up and picking up, which is more conducive to the management of the PUDO. In addition, some PUDOs will also be equipped with first-mile drop-off machines, monitoring equipment, and corresponding backend management systems to improve overall operational efficiency and enhance the customer's delivery and pick-up experience.

Overall, smart last-mile logistics solutions such as smart PUDOs have both advantages and potential challenges:

Advantages: Consumers can pick up multiple pieces at one time, which is labor-saving and convenient; it can have certain flexibility if the number of express delivery orders increases quickly.

Challenges: With various franchisees, it is difficult to guarantee service quality and replicate standardized franchises.

Case Study—Smart Transformation of a Self-service PUDO

Ordinary PUDOs require considerable manpower to sort parcels in and out of the warehouse, which is labour-intensive and error-prone. By changing the shelf layout and using smart tools and machines, PUDOs are

upgraded to become smart, allowing consumers to pick up their parcels. It effectively shortens the pick-up time of consumers at peak times, releases the staff's time and improves efficiency.

Pain points solved:

Improving efficiency: After the PUDO upgrading, some staff can take turns resting, while others can focus on to-door service. Fewer staff can complete the stock-in and stock-out of many parcels, which greatly improves work efficiency and reduces labour costs.

Assuring safety: Through video surveillance and other means, it can ensure the safety of parcels during customer pick-up, reduce disputes caused by lost or wrong parcels, achieve traceability, and reduce potential risks.

Value demonstration:

The open transformation helps realize orderly management, reduces the confusion and lost items caused by queuing up, and improves the customer experience. On the other hand, for PUDOs, automated equipment allows the station to use fewer people to meet the diverse needs of consumers, solving the problem of labor shortage, and there will be opportunities to expand other value-added services in the future. At the same time, the store's security facilities can ensure the parcel collection's safety and avoid disputes.

3.2.2 Smart locker banks

A smart locker bank is an automated mailbox machine that allows users to pick up and drop off parcels themselves.

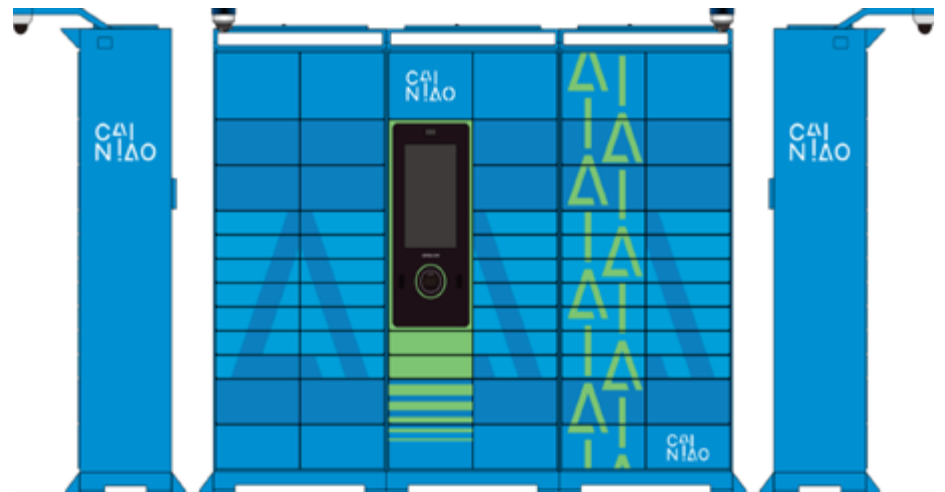
General core business scenarios of smart locker banks:

- Parcel sending and delivery service: courier pick-up and drop-off, consumer pick-up and drop-off, related remote operations, etc.
- Advertising service: Develop advertising business on locker compartments and screens
- Other services: Valued-add services such as waste goods recycling, shared washing machine, shared bookshelf, etc.

Core components:

- The hardware of lockers: Including each module of hardware, such as ARM machines, screens, scanners, network antenna, surveillance cameras, POS machines, audio, and so on
- Software of lockers operation system: software used by users like couriers and consumers with functions such as logging in, parcel sending, parcel picking up, payment and remote operation.
- Software of backend management system: operation management systems such as locker management, parcel management, and the management services like network routing and smart siting of PUDOs are included.

Figure 23: Example of Cainiao smart locker bank



Overall, **the smart last-mile logistics solution of smart locker banks has both advantages and potential challenges:**

- **Advantages:** For logistics companies and e-commerce platforms, locker banks with location advantages can provide 24/7 service, improve distribution efficiency, reduce the failure rate of first-time delivery, and provide consumers with a better experience. It can provide return service in an easier and lower-cost way.
- **Potential challenges:** In some markets, business models are unclear, and innovative value-added service in the short term is not profitable.

Case study—Cainiao & DHL locker bank cooperation program in Poland

Cainiao has strong capability of developing smart locker banks globally. Cainiao and DHL's cooperation project in Poland is one good example. By the end of September 2023, smart locker banks will be fully operational and will cover 10~20 cities in Poland.

Pain points solved:

- **Quickly build-up of a parcel locker network:** Based on years of experience and industry understanding, the project not only provides standardized solutions but also carries out customized transformation based on users' unique needs, to quickly establish the network.
- **Strong functions to meet multi-dimensional demands:** Except for meeting the needs of the couriers

and consumers operations and some basic backend management, it can also provide other necessary functions. For example, the backend management system of the cooperation project can show the view of lockers, which can monitor the current state of all locker compartments and promote the realization of remote maintenance and management.

- **Cost consideration:** Provide the most cost-effective solution of hardware, software, and operation & maintenance service, leveraging Chinese supply chain strength and engineer talent advantage.

Advantages:

• **The cost advantage of hardware:**

From a global perspective, the hardware of Cainiao's locker bank solution can rely on the supply chain advantage of China to achieve cost advantages.

• **Application advantage of software:**

The management system can fully understand customers' demands to improve the efficiency of operations relying on successful client experience. With several rounds of iterations, it can provide customers with multi-scenario support that conforms to local operations, covers abnormal scenarios, and optimizes the user experience.

• **Strong deliver capability:**

From the hardware perspective, the solution can be customized and provide choices of multiple modules. From the software perspective, based on the solution accumulation, customers' requirements of new business scenarios can be quickly

responded to with deliverables of short time and high quality.

- **Other capabilities:** Strong network extension tools can recommend locker bank locations according to the surrounding order volume and user data, which is very important in the early stage of business development, and can avoid choosing many inappropriate points when aiming to build a locker bank network quickly.

Value demonstration:

The Cainiao & DHL locker bank cooperation project in Poland has helped DHL expand its last-mile capability in the local market, and provide a better parcel pick-up and delivery experience for its users. At the same time, it also provides a solid foundation for DHL to expand revenue and reduce total distribution costs through locker banks.

3.2.3 Unmanned vehicles

Unmanned delivery vehicles are mainly used in the last-mile delivery of outdoor environments and are mostly used in communities, parks, and other scenes. Currently, the technology and small-scale production have been preliminarily realized, which can supplement the transportation capacity of the existing last-mile logistics delivery in the cities and effectively solve the problems in the closed park scene. In contrast, the unmanned distribution in the outdoor environment is more complicated, and the intersections are more complex, especially for the autonomous driving scenario, which has higher requirements.

Core business scenarios:

- Unmanned vehicle distribution in campuses: campuses are characterized by a large area, dormitories are distributed far apart, and there is a large parcel volume. The distribution of unmanned vehicles needs to meet the above characteristics and needs to face some specific problems while traveling, such as dense crowds, unstructured roads, road obstruction crossing, etc.
- Unmanned vehicle distribution in communities: In the community scenario, the main problem is the inconvenience of the distribution between community PUDOs and residential buildings. Unmanned vehicles can solve the problem well and deal with the scenes such as children playing, passing through community gates, and "intentional" bicycle rear-end collisions.

Current players include e-commerce platforms, logistics companies, and third-party enterprises such as Cainiao, JD, Nuro, and other leading companies that have begun to use unmanned vehicle technology to improve last-mile delivery service. They mainly provide intelligent and efficient unmanned distribution services in closed parks, campuses, and other scenes. They have initially realized large-scale commercial last-mile delivery services with unmanned vehicles. According to **Deloitte's research, some representative enterprises' unmanned vehicle delivery development status is shown in the table below.**

Figure 24

	Cainiao	JD	Nuro
Hardware of unmanned vehicles	<ul style="list-style-type: none"> • "Xiaomanlv" jointly developed with Damo Academy 	<ul style="list-style-type: none"> • JD's 5th generation intelligent delivery car 	<ul style="list-style-type: none"> • The 3rd generation unmanned delivery vehicle jointly developed with BYD
Development Characteristics	<ul style="list-style-type: none"> • Max load of 100 kg • Battery range of 102 km with 60 packages in a single trip • Large-scale application in communities, schools, parks and other scenes 	<ul style="list-style-type: none"> • Max load of 200 kg • Battery range of 100 km • Integrated the technologies of high precision maps and smart network linking • Applied in the scenes of parks and open roads 	<ul style="list-style-type: none"> • Load of 450 kg, can carry 24 bags of goods • Temperature control module • Max speed of 80 km/h • Applied on open roads
Long-term prospect	<ul style="list-style-type: none"> • Provide automatic distribution solution with high efficiency and experience and low costs 	<ul style="list-style-type: none"> • Deepen technology upgrade, terminal scene exploration, and standard precipitation 	<ul style="list-style-type: none"> • Achieve scale production and technology collaboration by cooperating with BYD
Current Stage	<ul style="list-style-type: none"> • Cover 70+ cities and 400+ universities in China 	<ul style="list-style-type: none"> • Distributed in main domestic cities, and cover several scenarios 	<ul style="list-style-type: none"> • Have mature practices in Texas, Arizona and California of USA
Challenges faced	<ul style="list-style-type: none"> • The technical dilemma of expanding application scenarios to open roads 	<ul style="list-style-type: none"> • The manufacturing and maintenance costs of unmanned vehicles are still higher than labor costs 	<ul style="list-style-type: none"> • Legal compliance issues of the implementation of transnational scale production

Source: Deloitte analysis, Cainiao Research Center

Core parameters (take Cainiao's "Xiaomanlv" as an example):

- Size. The "Xiaomanlv" has a size of 2100*900*1200mm (height of 1445mm if plus a lidar) and is colored in white and black, with rounded lines and a sense of cuteness. The fully

loaded vehicle can hold 60 packages in one trip; the highest parcel delivery volume in a single day is nearly 1,000.

- Speed. Considering the demand for safety in the last-mile delivery scenarios, the conventional speed of unmanned vehicles is below 15 km/h.

- Battery Range. Unmanned vehicles use a pull-out rechargeable battery with a range of 102 kilometers at 4 KWH per charge. The electricity it takes to drive 100 kilometers is less than that to eat hotpot for two hours.

Figure 25



Overall, **the highly intelligent last-mile logistics solution of unmanned vehicles has both advantages and potential challenges:**

- **Advantages:** Providing a contactless delivery service, which can reduce the security problems of delivery staff. Meet the needs of the diverse development of delivery demand and improve customer experience. Adapt to the order environment of high density, utilize order combination and route optimization to improve efficiency and standardize quality.
- **Potential challenges:** The overall manufacturing and maintenance costs are relatively high compared with labor costs, which restricts the scale production. Large amounts of sensors have the demand for performance innovation and iteration. At present, it is difficult to overcome the complex distribution roads and terrain and fully realize "to-door" service.

Case study—"Xiaomanlv" unmanned vehicles delivering during "Double 11"

During the "Double 11" in 2022, more than 700 "Xiaomanlv" was applied in campuses and communities across the country to deliver a larger number of parcels in a short time of up to 3 weeks, making it the largest unmanned delivery fleet in the industry.

Advantages of "Xiaomanlv":

- Firstly, intelligence with cognition and decision-making ability. It can drive freely in complex last-mile scenes, safely avoid obstacles, and smoothly handle turning, emergency stops, meetings, reversing and other situations, with an automatic driving rate of 99.9999%. It only takes 0.01 seconds for an unmanned vehicle to recognize the intentions of hundreds of pedestrians and vehicles. When there is a danger and the need to stop, it only takes 0.1s to make decisions, plan, and issue control instructions.
- Secondly, security with five safety designs. To ensure the safety and stability of the vehicle, the system architecture of "Xiaomanlv" has introduced five redundant designs, including brain decision-making, redundancy cerebellum, abnormal detection brake, contact protection brake, and remote protection.

- Thirdly, it can be massively produced with the capacity of scale production. Through self-developed algorithms and deep customization, the manufacturing cost of unmanned vehicles is reduced to the level of scale production. Core main sensors, such as chassis and lidar, are deeply customized—self-developed embedded heterogeneous computing platforms with high performance, low cost, and low power consumption.

Obstacles solved:

- Problems include a shortage of last-mile delivery staff, high parcel delivery costs, and low efficiency. With unmanned vehicle distribution in campuses and communities, the labor shortage problem was solved during "Double 11," when the parcel volume grew explosively. The overall distribution efficiency is increased, and the customer experience is improved.
- It is common for autonomous driving unmanned vehicles to meet the problem of being late, overall capacity and route planning. "Xiaomanlv" improves on-time performance and increases capacity by rationally dispatching various participants in the operation of the business, such as vehicles, people, parcels, etc.

Capability demonstration: 3.5 million parcels delivery during "Double 11", which demonstrates the technical capability of "Xiaomanlv", such as:

- The capability of the autonomous driving algorithm. "Xiaomanlv" identifies about 40 million obstacles daily and handles about 5 thousand interactions with other traffic participants.
- The engineering capability of the product system. By understanding vehicle driving situations and user service conditions, it can forecast and do real-time planning, which constantly breaks through the maximum vehicle delivery efficiency and capacity.
- The system's security guarantee capability and hardware stability capability. Under the heavy workload and extreme weather conditions during "Double 11", "Xiaomanlv" showed strong security and stability.

3.2.4 Drones

Drone delivery refers to the automatic delivery of parcels to their destinations via unmanned low-altitude aircraft. It is usually used to solve the distribution problem in remote areas, reduce delivery time, reduce labor costs etc. Challenges involve safety, cost, and weather constraints.

Core business scenarios:

- **Distribution scene of remote areas:** For example, in rural or remote suburbs and other places, due to the relatively large difficulties and high costs of building a last-mile logistics network, especially in rugged mountains, rivers and other places, drone coverage becomes an effective means. And the distribution of emergency supplies in remote areas during disasters.
- **Distribution scene of urban areas:** Cities have relatively more

flight restrictions. The current business scenarios mainly focus on conventional distribution in specific areas, such as medicine distribution, e-commerce small and medium-sized delivery, food delivery, and emergency distribution, such as the distribution of emergency relief supplies and medical emergency supplies.

Representative enterprises, such as JD, SF, Amazon, and other leading enterprises, have begun to use drone technology to improve the last-mile delivery capability to solve the problems in rural areas and other areas where logistics distribution will be difficult in the future.

According to Deloitte's research, the development status of drone distribution of representative enterprises is as follows:



Figure 26: Main Business Practices

	JD	SF Express	Amazon
Hardware of drones	<ul style="list-style-type: none"> • JD VTOL fixed wing drone for vertical takeoff and landing • JD drone with multi-rotor airfoil • Y-3 triaxial six-rotor drone 	<ul style="list-style-type: none"> • SF amphibious drone • Cooperate with Longxing to develop large drone with a load of over 1T • Fengyi ARK40 drone 	<ul style="list-style-type: none"> • Self-developed six-rotor drone Prime Air
Development Characteristics	<ul style="list-style-type: none"> • Achieve the speed of 100 km/h with a load from 2 kg to 60 kg • Drone with a load of 1T is being tested currently • The maximum mileage after charging can reach 1000 km 	<ul style="list-style-type: none"> • Powered by electricity, it can carry up to 50 km/h and can transport items weighing 10kg at a time • Amphibious and strong adaptability 	<ul style="list-style-type: none"> • It can carry 2.25 kg of goods and cover 75%-90% of express requirements in different regions • Adaptable for complex terrain • Landing buffering offsets shocks and protects transported products
Long-term prospect	<ul style="list-style-type: none"> • At least 70% reduction of logistics expenditure • Improve load/endurance with oil power 	<ul style="list-style-type: none"> • Air network coverage for small cities • Improve the efficiency of overall last-mile logistics 	<ul style="list-style-type: none"> • Drones can deliver items directly to the yards of consumers
Current Stage	<ul style="list-style-type: none"> • Regular drone delivery has been carried out in Shaanxi, Sichuan, Jiangxi and Jiangsu 	<ul style="list-style-type: none"> • Cross-region and intra-city drone delivery has been realized in parts of Nanshan and Futian of Shenzhen 	<ul style="list-style-type: none"> • Regular drone delivery service in Rockford, California, USA has been carried out
Challenges faced	<ul style="list-style-type: none"> • The battery endurance is insufficient • The manufacturing costs of batteries is relatively high 	<ul style="list-style-type: none"> • Small cities and remote areas have fewer airports, poor road network foundation, and the logistics timeliness is not ideal 	<ul style="list-style-type: none"> • Cannot maintain endurance with heavy cargo • Several safety incidents in the past

Source: Deloitte analysis, Cainiao Research Center

Core system components:

The system components of logistics drones include a flight system, ground control system, airborne mission equipment system, etc. Among them, a flight system is the core system of drones, which determines flight performance. A flight system includes a flight control system, navigation system, power system, and communication data system.

- **Flight control system:** The most important control system of a drone. The flight control system is like the "brain" of a drone. The drone can achieve full autonomous flight by sending commands and processing the data sent back by each component. The flight control system includes a flight sensor, an onboard computer, and a servo actuator.
- **Navigation system:** Realize the autonomous route planning of drones, and provide drones with reference coordinates, including positions, speed, attitudes, and other information. Currently, the navigation systems used by drones can be divided into non-autonomous navigation systems (GPS, Beidou, cellular network, etc.) and autonomous navigation systems (inertial navigation). The navigation accuracy and anti-interference ability of these two navigation systems still need to be improved.
- **Power system:** The basis of drones, which may directly affect flight reliability. With the deepening of

the research and development of drones and the growth of industry application demand, the power system is gradually evolving into small size, low cost, and high reliability. New energy sources such as solar energy and hydrogen energy are expected to become new power sources to provide more lasting endurance for drones.

- **Communication data system:** It is the key interface for data transmission and control of drones. The communication data system is mainly responsible for the transmission services of various systems on the UAV, including remote control, tracking, positioning, and sensor data.

Overall, **the highly intelligent last-mile logistics solution of drones has both advantages and potential challenges:**

- **Advantages include:** Reducing operation costs and reducing labor expenditure, improving efficiency, breaking road restrictions and overcoming complex distribution terrain. Promote industrial transformation.
- **Potential challenges include:** It is difficult for the government to approve airspace rights. High manufacturing and maintenance costs; The existing battery endurance needs to be improved. The cargo capacity is to be broken, and heavy parcels cannot be transported.

Cases: The solution of Company A—a leading medical supplies delivery drone service provider

Company A mainly focuses on the on-demand delivery of medical supplies. It is the world's leading drone logistics service company with many distribution centers. Its businesses include medical supplies delivery in various countries, retail express delivery and supporting the military with supplies delivery.

Pain points solved: One health institute searched for solutions to extend care into non-acute facilities and the home to build a first-in-kind decentralized care model. The partnership with Company A will provide prescription drugs and medical supplies to patients in a certain district. The business is expected to evolve over many years, eventually completing hundreds of deliveries a day and being able to deliver to approximately 90 percent of patients' homes in the region.

Value demonstration: Regular medicine delivery is provided to this healthcare facility, making it a reality for patients to enjoy real medical care at home. On the one hand, it can provide convenience, fairness, high efficiency, and patient reliability. On the other hand, it can provide a new service model for medical institutions, improving their service level and patient satisfaction and enhancing their operational efficiency and capacity.

3.3 Considerations and suggestions for players of the smart last-mile logistics market

Smart last-mile logistics is an important development direction to solve the "last mile" of logistics distribution in the future. According to data analyzed by Deloitte, global parcel volume is expected to double in the next five years, reaching about 270 billion by 2026, with a CAGR of more than 11% over the five-year period. The shortage of labor force in logistics distribution has always existed. With the intensification of aging and young people's pursuit of interesting work, the general trend for last-mile delivery is to improve efficiency and provide richer services by intelligent means.

From the perspective of **consumers**, smart last-mile logistics is a kind of "consumer-centric" service with obvious advantages:

- Consumers can enjoy 24/7 convenience and flexibility, can pick up parcels on the way, and can complete the first-time parcel delivery
- Contactless delivery to protect privacy
- Relatively low prices
- Environment-friendliness
- Parcels are not easy to lose

Consumer needs at the smart last-mile delivery is an important reference factor for all types of players, and is the most important dimension of the 4E model. The 4E model, which analyzes

the core advantages of smart last-mile logistics, can also help different types of players figure out whether they should develop or use smart last-mile delivery solutions. The four dimensions are of different relative importance to different types of players. This section will discuss the decision priorities of different players in detail.

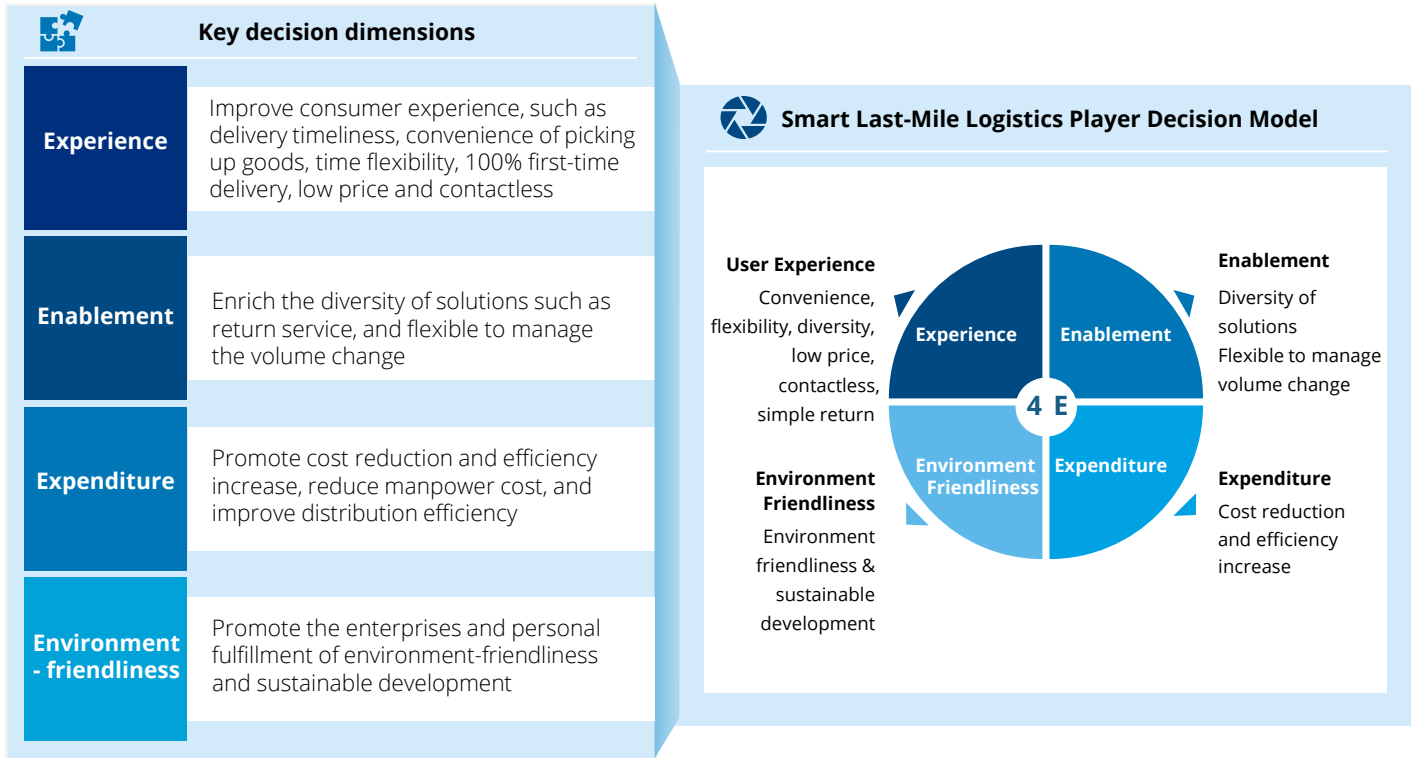
Key decision model for market players

After identifying and judging some target countries with high development potential of smart last-mile logistics applications, core players need to make comprehensive evaluations and decisions on whether to deploy or use smart last-mile delivery in specific target markets based on the situation of the target local countries and around the requirements of last-mile logistics experience, enablement, expenditure, and environment-friendliness.

3.3.1 Consideration factors of logistics companies

Logistics companies here include postal companies, express companies, etc. In the development and construction of the smart last-mile logistics application, they are mainly responsible for building the business models and integrated technology solutions of the last-mile delivery and executing the distribution of last-mile logistics. Based on the potential considerations surrounding specific business, **the decision model should be built and judged (Figure 27):**

Figure 27



Source: Deloitte analysis, Cainiao Research Center

Considerations of whether to apply "smart last-mile logistics solutions" or not:

- Experience:** The intensity of the OOH network is the primary factor in improving the user experience of convenience. As a scarce resource, the core point must be planned for last-mile service providers. Through the dense coverage of smart last-mile in the core area, **logistics enterprises can acquire users faster, forming a positive cycle, achieving high customer retention, and establishing competitive advantages.**
- Expenditure:** Last-mile delivery is the biggest cost driver in logistics. From the holistic perspective of logistics service providers, smart locker banks/smart PUDOs can **improve distribution efficiency and reduce labor costs.** However, they have fixed and related maintenance costs in the early stage. If the amount of cooperation orders is sufficient, the cost of using lockers is lower. Meanwhile, **a high success rate of first-time delivery also means cost savings.**
- Enablement:** A last-mile station network will **maximize the sustainable capacity** of the overall supply of logistics parcels, **bringing more revenue and value** to logistics enterprises and social logistics. It also allows enterprises to develop wider and more complete business coverage by relying on the last-mile station network to enhance **brand influence.** At the same time, **traditional logistics enterprises** such as postal service companies and traditional freight giants are also **facing the pressure** brought by the last-mile delivery model of e-commerce, so logistics enterprises also need to expand new business channels.

- **Environment-friendliness:** Consumers have an increasing awareness of environmental protection. **For companies, being green is no longer a choice; rather, it has become a consumer preference and social choice.**

Judgments on self-owned /leasing:

- **The advantage of self-owned equipment is that it can seize and own scarce location resources and be closer to consumers.** In the long run, the distributed expenditure is lower if the order volume is sufficient.
- **The advantage of leasing is that it can balance the expenditure in the short term.** Due to the large initial equipment investment, the cost recovery will be slow if the order volume is insufficient. As a result, leasing service is flexible and can be well validated, especially at the early stages of a project.
- If choosing the self-owned equipment, the overall capability of the supplier should be considered, which means it is able to **develop hardware and software solutions quickly with high quality** based on previous experience and industry precipitation. It can provide users with high-quality OOH equipment and service experience while catching up with the time window at the same time.

3.3.2 Consideration factors of e-commerce platforms

E-commerce platforms are usually the users of last-mile delivery in the development of smart last-mile logistics applications. However, it is also increasingly involved in constructing a last-mile delivery network, especially

e-commerce platforms with a certain scale. Its primary goal is to serve the last-mile logistics of parcels on its platform, and it will also consider other forms, including network sharing with other logistics companies. Amazon Hub Locker, for example, supports Amazon parcels only, but Amazon Apartment Locker accepts parcels from all express delivery participants. Based on potential considerations surrounding specific business development, **the decision model of e-commerce platforms should be developed and judged.**

Considerations of whether to apply "smart last-mile logistics solutions" or not:

- **Experience:** For e-commerce platforms, the core role of smart last-mile solutions is to improve **consumer satisfaction**. Besides considering consumers' core characteristics, e-commerce platforms must provide consumers with delivery methods that suit their preferences and meet their needs in terms of convenience, flexibility, cost, and other aspects.
- **Enablement:** Utilize smart last-mile delivery applications and infrastructure settings to open the **return service capability** in the business flow and to provide consumers with freedom and convenience to carry out activities such as goods returning. Meanwhile, it is **flexible to sudden volume changes** during some sales festivals compared with home delivery.
- **Expenditure:** The applications of smart last-mile solutions can **improve distribution efficiency, reduce distribution costs,** and

generally reduce the cost of e-commerce platforms. It can transfer the cost reduction to consumers to strengthen self-competitiveness or reduce costs.

- **Environment-friendliness:** More and more consumers have higher demands for environment-friendliness and sustainable development. Especially when competitors have relevant layouts, the lack of "environment-friendliness" will become a weakness. From the perspective of the enterprise itself, it should also take this into full consideration and take the fulfillment of ESG responsibility of large enterprises as one of the key factors.

Judgments on self-owned/leasing:

- **The core consideration of self-owned facilities of OOH is to avoid the systemic risk of high dependency.** Some e-commerce platforms mainly rely on logistics service providers for smart last-mile logistics, which involves price increase risks and systematic risks due to service interruption when the reliance proportion is high. Therefore, it is necessary to consider self-construction and master the right of operation. At the same time, self-owned equipment can **improve the stability of punctuality and avoid making consumers dissatisfied** with the logistics service.
- **The core consideration of leasing is cost.** The initial investment of self-owned equipment is large, and leasing could be better if the parcel volume of the e-commerce platform is not large enough.

4. Summary and prospect



Looking into the future, with the irreversible trend of population aging and the stable development of e-commerce, the application and expansion of smart last-mile logistics are increasingly important. The rapid development of InPost's OOH network, especially the locker banks in Poland, also boosted market confidence. After focusing on the e-commerce parcel market in 2017, Inpost went public four years later with a market value of up to 10 billion euros. The entry of traditional logistics companies in Europe and the abundant cash flow of shippers and freight forwarders have accelerated the related acquisitions, and the smart last-mile delivery market is becoming increasingly bustling and competitive.

To summarize this report, smart last-mile service providers such as logistics enterprises and e-commerce platforms may consider taking action through the following steps:

Firstly, conducting target market analysis and research. Analyze the trend of smart last-mile logistics in different local markets according to specific conditions, including future economic development, parcel volume forecast, consumer preference, technology development, market players' competition and other factors. The "smart last-mile logistics market landscape" has referential value for that.

Secondly, having a clear, comprehensive strategy for smart

last-mile logistics. Enterprises are encouraged to establish their strategies based on external analysis, internal development goals in both long and short terms. The "4E Model" can be adopted when making decisions on smart last-mile logistics. Meanwhile, it is required to clarify the target regions, capacity and volume, functions (e.g., return service), pilot city, the way to provide service (self-owned or leasing), and the way to develop the capability (cooperate with partners or operate independently by subsidiaries).

Finally, clarifying the implementation plan and equipped with resources for control. For example, the OOH network points planning is carried out to avoid selecting inappropriate locations due to the rush of time, thus affecting results. In terms of effective use of resources, logistics companies may continuously cooperate with current multinational merchants in new markets and pre-signing some parcel delivery orders. Meanwhile, the current team can serve as the headquarters to provide horizontal support for market expansion.

The smart last-mile logistics market is setting sail for future advancement. We sincerely hope that the insights and analysis in this report can contribute to readers in terms of understanding the development trend and making future decisions on smart last-mile logistics.

Glossary

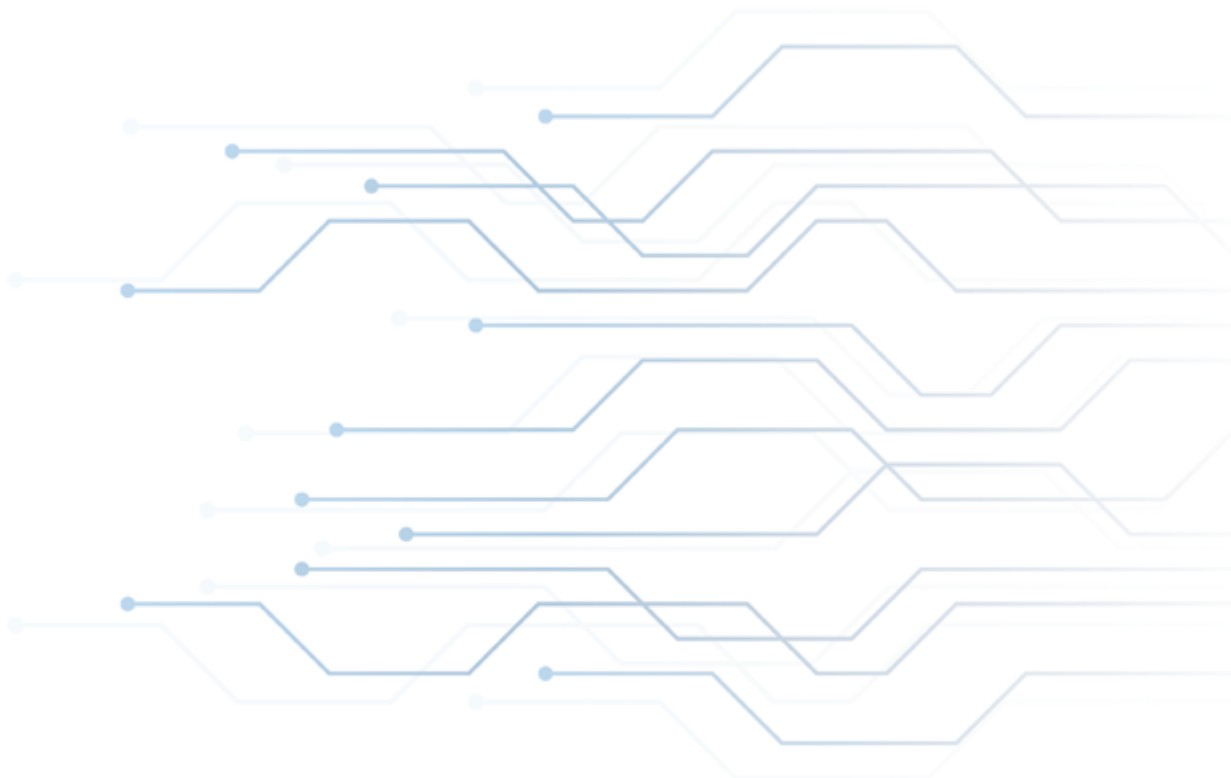
To-door delivery: Also known as home delivery or door-to-door delivery, is a shipping service that delivers items directly to the recipient's home.

OOH: Out-of-home delivery is a concept opposite to to-door delivery, mainly including pick-up and drop-off points (PUDO), locker banks, etc.

PUDO: Pick-up and drop-off points are places where one can collect a parcel. They can be convenience stores, grocery stores, parcel shops, post offices, retail stores (click & collect), etc.

Locker bank: Another name for automated parcel machines (APM) or parcel lockers is an automated mailbox machine that allows users to pick up and drop off parcels by themselves.

Click & Collect: A hybrid e-commerce model in which people purchase or select items online and pick them up in-store or at a centralized collection point.



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About Cainiao Research Center

Relying on Cainiao and Alibaba Group, the Cainiao Research Center has a wide range of businesses scenarios and industrial practical experience, combined with Cainiao's advantages in globalization, logistics technology, green and global emergency, etc. We are committed to serving consumers, merchants and logistics partners with deep insights and long-term value.

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