

Research on the Growth Mechanism of Express Delivery Industry Based on System Dynamics

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Abstract: In the past few years, the express delivery industry has experienced a decrease in its previously fast growth rate. To better understand the reasons behind this slowdown, this research paper researches the interconnections between the key entities in the express delivery industry using a causality diagram. Additionally, it explores the factors that drive the industry's growth and those that limit it, based on the industry's historical development. Using system dynamics, a model is constructed and validated. The study reveals that the factors contributing to growth in the express delivery industry include advancements in express business and technological innovation, the influence of e-commerce, policy support and logistics infrastructure. On the other hand, the factors that hinder growth in the industry include a shortage of human resources, excessive dependence on e-commerce, and insufficient infrastructure. Finally, the paper identifies and analyzes the key factors for modeling purposes, and the simulation results confirm that these selected factors significantly affect the development of the express delivery industry.

CCS CONCEPTS • Applied computing • Operations research • Consumer products

Keyword: System Dynamics; Express delivery industry; Growth mechanism

1 INTRODUCTION

In 2021, China witnessed a milestone in its express delivery industry, with a record-breaking volume of over 100 billion deliveries, as illustrated in Figure 1. Based on the analysis of historical data, we can observe a strong connection between the growth of the express delivery industry and the development of e-commerce. There is a positive correlation between the volume of express delivery services and the online sales of physical goods, as depicted in Figure 2. Starting in 2020, the rate at which online retail sales of physical goods increase has decreased to below 30%. Similarly, the growth rate of the express delivery industry has also dropped below 30%. Hence, conducting a comprehensive examination of the growth mechanism of the express industry, particularly the impact of the e-commerce industry on its growth and limitations, holds immense practical importance for fostering the overall industry's healthy development.

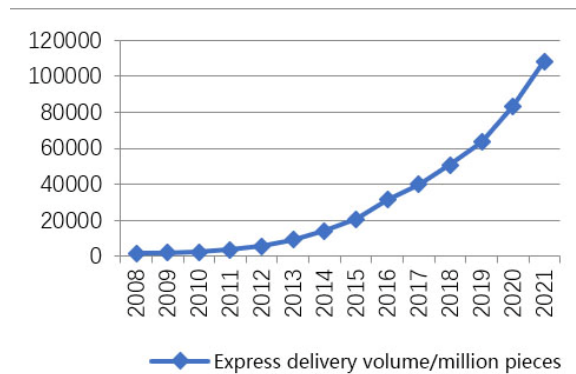


Figure 1: Growth trend of express delivery business volume



Figure 2: Trend of express volume and online retail sales

Zhang Ya^[1] employed various methods such as factor analysis, linear weighted summation, and collaborative order parameters to assess the connection between the express delivery industry and e-commerce. Through regression analysis, it was determined that the collaborative development of the e-commerce and express delivery industry is influenced by factors such as the level of economic development, consumer consumption, informatization, and government support. Ji Tong^[2] utilized the SCP paradigm theory to analyze micro-factors, including human resources and infrastructure, that impact the development of the express delivery industry. Additionally, the industrial correlation theory was employed to determine macro-factors such as e-commerce, logistics, and transportation facilities. The gray correlation method was used to quantitatively analyze the relationship between related industries and the express delivery industry. Scholars employ various methodologies to investigate the factors that influence the express industry, but they rarely utilize the system dynamics theory. The primary advantage of system dynamics lies in its holistic and rational approach to considering the entire system, as opposed to isolated system mechanisms^[3]. In this research, we examine the growth mechanism of the express industry by constructing a model from the system dynamics perspective.

2 QUALITATIVE ANALYSIS OF EXPRESS INDUSTRY GROWTH MECHANISM

To comprehensively research the growth mechanism of the express delivery industry and establish a basis for constructing a simulation model, this study initially analyzes the structural relationships among the key entities in the express delivery industry using a causality diagram. Causal diagrams can illustrate the configuration of the system including system variables, the interconnection among the variables, and the cyclical patterns.^[4] These diagrams will be utilized in this study to delve deeper into the courier industry.

According to the data on the volume of express business, we can observe an S-shaped growth curve. This suggests that the growth of the express industry is influenced by both factors that promote growth and factors that limit growth. The causal diagram is shown in Figure 3. The figure shows two positive feedback loops and one negative feedback loop. One positive feedback loop highlights how an increase in express business volume drives the development of the express industry. As the express industry develops, the service level of the industry improves. However, this development also leads to a reduction in the available space for further growth, which in turn reduces the volume of express business. This negative feedback loop is a key factor contributing to the slowdown of the express delivery industry. Conversely, the factors within the positive feedback loops are crucial in promoting the rapid development of the express delivery industry.

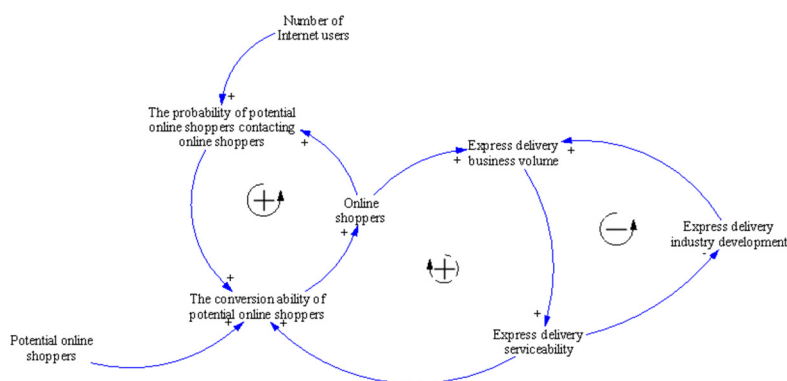


Figure 3: Causal loop diagram

3 ANALYSIS OF DRIVING FACTORS OF EXPRESS INDUSTRY GROWTH

3.1 Business innovation

The express delivery industry has transitioned from a period of rapid growth to a phase of high-quality development. The primary focus of business innovation has shifted from speed to improving the level of service. With the increase in demand for the rapid transmission of

international samples, documents, business letters, and information during the period of reform and opening up, there was a need to enhance the speed of express operations to meet market demands^[5]. This became the main focus of the express industry's development at that time. It is this focus that led to the establishment of our first international courier service in 1980. The express delivery industry witnesses its inaugural business innovation.

However, the express industry has gradually become unable to keep up with the increasing demand for fast delivery. As a result, the express industry has experienced significant changes and new developments. This has led to a new era of speed and innovation in the industry. The need for same-day express delivery between the Pearl River Delta region and Hong Kong has led to the establishment of China's first private express company, SF Express, and the emergence of STO Express. Since 2007, the rapid growth of e-commerce has introduced new operational concepts to the express industry. Express companies like SF Express, STO Express, and YTO Express are no longer limited to commercial correspondence or small-scale business deliveries. They are expanding their services to encompass the entire e-commerce market. Now, every consumer's e-commerce order contributes to the demand for express delivery, and this innovative approach has led to a rapid increase in the volume of express business.

3.2 Technological innovation

The technological innovation of the express delivery industry relies on business innovation, and the development focus has also changed from speed to service level. In the early days, the efficiency of express delivery operations was limited due to the relatively low technical capabilities of the facilities and equipment used. However, technological innovation brought about progress with the invention and creation of letter-sorting machines and parcel-sorting machines. As information technology advances, the express delivery industry has embraced digitalization, integration, and high efficiency. The widespread usage of wireless Internet technology, satellite positioning technology, and geographic information systems has enabled the provision of cargo tracking services to customers. Additionally, RFID technology and barcode technology are utilized to offer customers convenient one-click scanning services.

Technological innovation encompasses all aspects of the express delivery industry, but the progress of each stage varies. This includes front-end package collection, warehousing, transportation, end distribution, and information management. The rapid advancement of the Internet of Things, big data, and cloud computing technologies has expedited the integration of traditional express delivery equipment with robots, artificial intelligence, and other technologies. Express industry technology is blooming in every link, but the technological development of each link is not balanced. Front-end package collection, warehousing and transportation have been basically improved in the supply chain system, and are developing towards more information, integration and efficiency, while the terminal distribution and information management are in the initial stage of development, and it will take some time to be more perfect.

In addition, every express delivery company is involved in this development, but each company has different priorities. Express delivery companies are using various measures such as purchasing or developing new intelligent robot equipment, launching application software, and integrating technology to accelerate the intelligent, information and integrated development of the industry. Cainiao concentrates on research and development in terminal

distribution. They have launched technology products specifically designed to enhance terminal distribution capabilities, such as the unmanned vehicle "Small G plus", " Cainiao Box ", " Cainiao Express Tower" and " Logistics Eye ". Jingdong is dedicated to establishing an "unmanned" supply chain system. The successful establishment of the "Jinghong" unmanned cargo aircraft marks their achievement in the whole process of drone research and development, production and supply chain management and control system. Each express delivery company is carrying out technological innovation, and the development focus is different according to the actual situation of the enterprise.

3.3 E-commerce demand drives the development of express delivery industry "golden period"

E-commerce has played a significant role in driving the growth of the express delivery industry. In 2007, e-commerce made its official entry into the express delivery sector, bringing new opportunities for growth. The rise of popular e-commerce platforms like Taobao and Jingdong has led to a surge in online shopping, making e-commerce express delivery a key driver of the express delivery business. Currently, e-commerce shipments account for more than 60% of the total express shipments in the country, and in the private express delivery sector, e-commerce orders make up more than 80% of the business. This clearly shows that e-commerce has become the primary force behind the development of China's express delivery industry.

3.4 Policy support

Since 2007, the express delivery industry has been receiving support from policy dividends. The State Council and other relevant departments have issued a series of policies to promote and regulate the development of the express delivery industry.

The Postal Industry Development "14th Five-Year Plan" proposes to extend express logistics services to rural areas to promote rural consumption, which will expand the overall coverage of the express delivery industry, and promote China's express delivery industry from high-speed growth to high-quality growth. In response to the state's call, different provinces and cities have also introduced policy recommendations tailored to their local conditions, providing robust support for the development of the express delivery industry across the country.

3.5 Logistics infrastructure

Ever since the 18th National Congress of the Communist Party of China, there has been an increased focus on the development of transportation infrastructure in China. According to data derived from an article in the People's Daily, from 2012 to the end of 2021, rail and road mileage increased by about 1.1 million kilometers. The road network has achieved extensive coverage, and by 2022, the density of the road network reached 55 kilometers per 100 square kilometers. The railway network has also expanded in all directions and has formed a safe and efficient network with a reasonable layout, extensive coverage, and a clear hierarchy.^[6] These improvements in road and railway infrastructure have resulted in faster transportation speed and improved conditions for the express delivery industry. This has provided favorable conditions for the growth and development of the express delivery industry.

A logistics park serves as a hub for multiple logistics service providers, offering an ideal environment for logistics enterprises to grow and thrive. It plays a crucial role in driving the development and progress of the logistics industry. Since 1998, there has been a significant increase in the number of logistics parks in China. Data are obtained from the "Sixth National Logistics Park (Base) Survey Report" in 2022 and it's found that there are 2,553 logistics parks of all kinds in the country meeting the basic conditions of this survey in 2022, an increase of 55.9% over the 1,638 in the fifth survey in 2018. In the past four years, the total number of logistics parks in China has an average annual growth rate of 11.7%, and the growth rate has maintained a relatively fast trend on the whole^[7].

4 ANALYSIS OF LIMITING FACTORS OF EXPRESS INDUSTRY GROWTH

4.1 The limitation of human resources in express delivery industry

The scale of express delivery in China is constantly increasing, and express delivery employees have been in a state of high demand, and the long-term supply of labor force in the express industry is insufficient. Moreover, the human resources of express industry are mainly primary human factors, and senior human factors are very scarce. The entry threshold for express delivery practitioners is very low and there is no skill requirement, resulting in most of the labor force coming from personnel with lower educational experience, which is concentrated in low comprehensive quality. Express practitioners are directly customer-facing, and the comprehensive quality of express practitioners is crucial for express enterprises to develop new customers and consolidate old customers. If the comprehensive quality of express practitioners is not up to standard, it will lead to an increase in the dissatisfaction rate of customers, and it will be impossible to retain customers, limiting the development of the express industry.

The high level of employee turnover in the express industry hinders its development. The express industry is characterized by low entry and exit barriers, limited welfare, unstable income and high work intensity. This often leads to many practitioners using courier jobs as stepping stones in their careers, making it difficult to retain them for a long period of time. The significant turnover of employees is detrimental to the development of the express industry.

4.2 Over-reliance on e-commerce

The development of express delivery is closely linked to the growth of e-commerce. E-commerce heavily relies on express delivery services, and the two have become closely intertwined. However, this relationship can be both beneficial and detrimental. E-commerce customers are highly sensitive to prices, and the major e-commerce express delivery companies offer similar levels of timeliness and service. This has led to a dilemma in the industry known as "the race to the bottom" in terms of pricing. In order to gain market share and have control over pricing, some companies resort to offering subsidies, leading to the formation of an oligopoly or dual oligopoly pattern. This has resulted in a price war in the express delivery industry, as price has become a key point of competition in a market where services are increasingly similar. The concentration of e-commerce delivery has also caused

an imbalance in the distribution of demand for express services, further intensifying the price war in the industry. Price wars are extremely detrimental to the development of the industry

With the competition of e-commerce giants in Ali, Pinduoduo, and Jingdong three kingdoms stage, express companies are obviously divided into several camps: Ali series (YTO, STO, Best), Pinduoduo series (Jitu), Jingdong series (Jingdong logistics), higher independence of the third party (SF Express, Zhongtong, Yunda)^[8]. If the total demand for e-commerce is stable, the Courier companies that rely on e-commerce support can get stable development, and if the e-commerce giants change, the Courier companies will also be turbulent, which is not conducive to the development of the entire Courier industry.

4.3 Infrastructure

The infrastructure in rural and underdeveloped areas is relatively underdeveloped, with a low penetration rate of logistics outlets and internet access compared to urban areas. This has resulted in a lower level of development in the express delivery industry in rural areas.

5 SD MODELING OF EXPRESS INDUSTRY GROWTH

5.1 Build a model

The data utilized in this research is sourced from the National Bureau of Statistics.

This paper constructs a model that is based on the factors that drive and limit the growth of the express delivery industry (Figure 4). To simplify the calculations, only the most significant factors are chosen and appropriate functional relationships and parameter values are established for modeling purposes.

The step length of the simulation model is 1 year, the year 2008 is the year 0, and the total running time is 13 years, ending in 2021.

The main equations are explained as follows:

Conversion rate: This refers to the rate at which potential online shoppers are converted into online shoppers. It is related to the probability of potential users contacting online shopping users and the acceptance ratio (of potential online shopping users to online shopping). So the equation is set as Potential online shopping users * Contact rate of potential users * Probability of potential users contacting online shopping users * Acceptance ratio.

Probability of potential users contacting online shopping users: The ratio of online shopping users to Internet users represents the probability of developing into online shopping users in the Internet user group. so the equation is set as: The total number of online shopping users/Internet users.

Acceptance ratio: It depends on the service efficiency of the express industry, if the service efficiency of the express industry is greater than 0.5, then the acceptance ratio is 0.4* the service efficiency of the express industry, if the service efficiency of the express industry is less than 0.5, then the acceptance ratio is 0.33

Potential user contact rate: Only non-online shoppers who contact network users are considered potential users. Therefore, set this parameter to 1.

Per capita express delivery volume: The real data and simulation data of express delivery volume from 2008 to 2021 are fitted respectively, and parameters are obtained according to trend analysis. The equation is set as: $0.086 * \text{Time} - 0.011$.

Express business volume: Online shopping users * Per capita express delivery, this formula can get the express business volume.

Service efficiency of express delivery industry: It's determined by the development limit of express delivery industry and the volume of express delivery business, the formula can be expressed as $(\text{Express delivery industry development limit} - \text{Express delivery business volume}) / \text{Express delivery industry development limit}$.

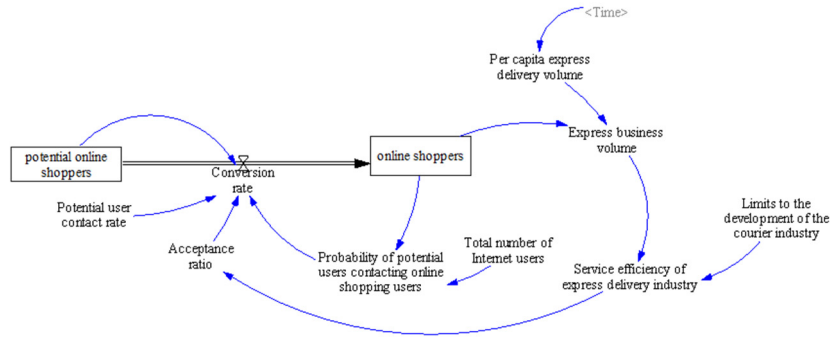


Figure 4: System dynamics model

5.2 Model verification

The model's validity is assessed by comparing real data with simulation data. The Figure 5 shows that the trends in express delivery business volume and simulation data are similar from 2008 to 2021, with a small difference. Additionally, the number of online shoppers aligns with the model, indicating its practical significance as in Figure 6. The selected important factors also have an impact on the development of the express delivery industry.

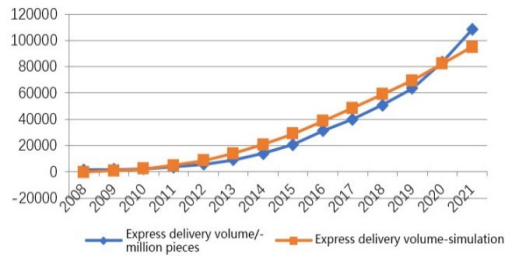


Figure 5: Express delivery volume simulation

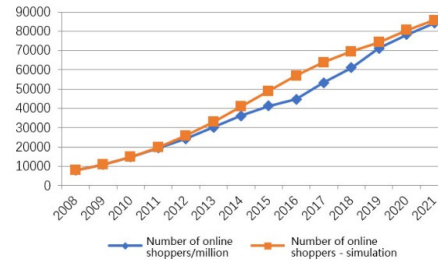


Figure 6: Online shopping number simulation

6 CONCLUSIONS

This study identifies three key drivers for the growth of the express delivery industry. Firstly, business innovation and technological innovation are crucial factors that are closely intertwined. The focus of development has shifted from speed innovation to service innovation. Secondly, the rise of e-commerce plays a significant role in the rapid development of the express delivery industry. Lastly, policy support and logistics infrastructure are important contributors to the industry's growth. However, in recent years, the industry's growth rate has slowed down, and its drawbacks have started to surface and impact its development. Insufficient employee numbers and inadequate professional qualifications fail to meet the demands of modern consumers. The industry's over-reliance on e-commerce has resulted in price sensitivity, homogenization, and price wars, which are detrimental to its development. Moreover, the lack of sufficient infrastructure in rural and underdeveloped regions serves as a significant constraint on the expansion of the express delivery sector.

Based on the fundamental concept of system dynamics, this research integrated the factors that promote and restrict the growth of the express industry. The Vensim software component model was employed to analyze and verify the model. Simulation results were obtained and compared with the actual data, confirming that the growth and limiting factors identified in this study do indeed influence the development of the express industry.

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