Delft University of Technology

Research on Urban Logistics System Strategy Based on System Dynamics: A case study of ChongQing

Jiaqian Liang
Engineering and Policy Analysis
Faculty of Technology, Policy and Management
Delft University of Technology
June 21th, 2021

Title Page

Title	Research on Urban Logistics System Strategy Based on System Dynamics: A case study of ChongQing
Author	Jiaqian Liang
Date	June 21th, 2021
Email	liangjq92@126.com
University	Delft University of Technology
Faculty	Faculty of Technology, Policy & Management
Program	
Graduation Committee	Luning Liu (President) Hongyu Zang (First Supervisor) Els van Daalen Xiaofeng Hui

Executive Summary

In recent years, living needs of residents have been greatly enriched. **The development of urban logistics industry is increasingly important for the overall development of the city**. At the same time, in the context of China's remarkable improvement in urbanization and the rapid increase in urban population, the development of urban logistics is also facing many problems. **First**, high-density logistics demand in cities has **increased the difficulty of organization and management**. **Second**, urban logistics has to face urban land use planning and **limited resource allocation**. **Third**, urban logistics will have an **external uneconomic impact** on the urban environment, transportation as well as economy activities. The **sustainable development** of urban logistics and **the interaction** between logistics activities and other aspects have become an urgent research subject.

The urban logistics system is taken as the research object in this thesis. In order to solve the problems existing in the modern urban logistics system in China, **scientific planning methodology and feasible strategies are proposed** in this article, aiming at improving the development of the logistics industry and promoting the sustainable development of cities in China. In order to be more realistic, a **case study** is employed. **Chongqing**, the representative city of the central and western regions of China, is selected as the study case object. Unlike other old-fashioned first-tier cities in China, Chongqing has experienced **the process of rapid industrialization**. The analysis of Chongqing has a good reference for many of China's quasi-first and second-and-third-tier cities. Through the analysis of the background of urban logistics development and literature research, the core **research question** of this thesis is put forward. "How can we propose a reasonable development **strategy to promote the sustainable development of modern logistics in Chongqing** while ensuring the optimal results of the entire system?"

In order to explore this problem, this paper begins with an analysis of the **urban logistics system architecture**, **the role of public policy**, the **evaluation standard** for the development of urban logistics system, and conducts an in-depth study on the **status quo and challenges** of the logistics industry in Chongqing. The analysis results show that Chongqing logistics faces four major difficulties. **Firstly**, the global trade volume and logistics demand is shrinking. **Secondly**, logistics corporations is scattered and lack of modern technology and services. **Thirdly**, there is a greate shortage of senior logistics talent. **Fourthly**, the traffic congestion in the main urban area is severe. Based on the theoretical analysis and research, a **system dynamics model** is constructed. The model highly simulates the internal supply and demand structure and historical data of the logistics system in Chongqing. Through the analysis of the model operation, the **comprehensive effect of several strategies** on various evaluation criteria are **simulated and analyzed** in this paper, including promoting the growth of trade demand, improving modern service capability, attracting logistics talents and alleviating traffic congestion. Based on the simulation results, the **optimal policy suggestions for the sustainable development** of urban logistics in Chongqing are put forward.

Table of Contents

Abbreviations

CFLP	China Federation of Logistics and Purchasing
CLD	Causal loop diagram
TAC	Transportation Association of China

1. Introduction

1.1 Research background and significance

1.1.1 Research background

In recent years, changes in production mode and advances in science and technology have enabled the global economy to develop rapidly. Connections between companies are closer. The global economy seems linking by an invisible chain. While production efficiency continues to increase, resources are becoming increasingly tense, and the space for reducing production cost has become quite limited. Traditional methods are no longer sufficient to promote sustained and rapid economic growth. It is **urgent to seek new opportunity for economic growth**.

In this context, **logistics industry**, relying on its unique advantages, is increasingly regarded as "**the third source of profit**" on a global scale, followed the resources and productivity (Bowersox,D.J.,Closs,D.J.,&Cooper,M.B., 2002). The development of logistics will drive the overall development of a region and improve the degree of openness to the outside world. In the early days, people talked more about the corporate logistics and the third-party logistics. However, there are **relatively less discussion on urban logistics**, and the **relationship between logistics and region development** (Hong, 2006).

Generally speaking, the development of logistics industry in developed countries has gone through four stages (TAC, 2002). **The first stage** is the separation of logistics storage and transportation before 1960s. Many factories and individuals build warehouses, which are closed and only have storage function. **The second stage** was from 1960 to 1980, during which more and more products were produced. The storage period becomes shorter and shorter, and it was developed from "storage type" to "circulation type". The concept of "distribution" was generated. The warehouses were migrated from the center to the suburbs of the city. **The third stage** is 1980-1990 years. With the development of computer, information processing function has been added to warehouse and distribution center. Logistics has been changed qualitatively. 95% of warehouses became single-layer three-dimensional warehouses and many warehouses became distribution center. **The fourth stage** is since 1990, and the term "**urban logistics**" was fisrt used in 1990s. Logistics has developed into an intensification stage. On the basis of making full use of all resources, modern management and technology are used more centrally and rationally, giving full play to the positive effect of human resources, further improving the efficiency and effectiveness of logistics. Besides storing and transporting goods, many value-added services have been provided, which are more oriented to consumers.

1.1.2 Research significance

The **research on logistics industry** has many contributions to other industries as well as to urban economic development, mainly in terms of contribution to urban GDP, industrial form, economic structure adjustment, and meeting social consumption needs.

The contribution rate of the urban logistics industry to the urban production value is a key indicator to measure **the degree of marketization of the city economy**. The contribution rate of the production value of urban logistics to GDP is related to the marketization degree of goods and services, and intermediate demand rate in the country (Shuang, L., 2010). The higher the degree of marketization of goods and services and the higher the intermediate demand rate, the greater the contribution of logistics industry to the gross national product. Modern logistics industry has become a most effective way to promote urban economic growth as an emerging comprehensive service industry, supported by modern information technology and modern management concepts. From the aspect of market operating costs, the outstanding performance of the logistics industry is the reduction of general social transaction costs. From the aspect of the transaction process, the development of the modern logistics industry can greatly reduce the cost of searching for transaction object information and reduce various compliance risks. From the aspect of the behavior of the transaction subject, the development of the modern logistics industry will reduce the transaction costs arising from the "limited rationality" of the transaction subject. The main body of modern logistics industry is a network system consisting of many nodes and lines, while a stable and efficient logistics network can not only reduce wear and transaction costs between components, reduce the cost of users using network resources and elements, but also amplify the features of each element to increase the benefits of the elements and the entire network.

Modern logistics can **bring in a new industrial form of the city, with the economic structure adjusted and optimized**. According to the evolution of industrial structure, the development direction of urban industrial structure is rationalization and advance. The rationalization is measured by the level of development of the tertiary industry. The advance means upgrade from the primary industry to the secondary and tertiary industries, with transmission from labor-intensive industries to capital and technology-intensive industries. Actually, the essence of modern logistics industry is the tertiary industry, which results from the high development of modern economic division and specialization. The development of the logistics industry will promote the development of the tertiary industry, which will further bring about the accumulation of business, capital, information and technology flows, as well as transportation, commerce, finance, information, tourism, and many other industries, which are new growth points for the tertiary industry development(Kovács, G., & Kot, S., 2016).

Modern logistics industry can better **meet the needs of social consumption**. The transformation from production to consumption must be realized through the circulation of production materials and living materials. The traditional commodity circulation industry is usually completed independently by wholesale or retail business organizations, while the modern logistics industry improves the circulation operational efficiency, and highlighting the logistics profession level, with the help of modern applied science and technology (network information technology, communication technology, transportation technology, etc (Pokharel, S., 2005). Moreover, logistics activities can also be used as an effective tool for marketing activities during production and circulation, and to a large extent can have a positive impact on the consumption structure, consumption patterns and consumption trends. it not only meet the social Demand for product range, convenience of purchasing goods, and services, but also guide and change demand concepts, and even create demand (Shijin, W., 2013).

1.2 Concept distinction

Urban logistics refers to the freight movement serves for cities. It serves the needs of urban economic development, playing as an integral part of the urban economy. Based on this, urban logistics concept can be described as the **physical flow of goods within the city, the distribution of goods, and the process of urban waste cleaning** (CFLP, 2002). On the basis of comprehensive considerition of various modes of transportation, urban land use planning and road network planning, the urban logistics system maximizes the integration and optimization of logistics resources. It aims to reach overall optimility by considering the interaction between urban logistics and society, economy, environment and urban transportation.

Urban logistics is a kind of **regional logistics** relying on cities. It has a higher concentration and is more important for the economic and social development of the city. At the same time, it has a greater negative impact on urban economic and social development. With the development of the city, the scale of urban logistics is expanding, and the external diseconomies of urban logistics are becoming more and more obvious, such as traffic congestion, noise generation, environmental pollution, traffic accidents, and deterioration of living environment. Due to the high concentration of population, business, information and logistics in the city, the external diseconomies is more concentrated and prominent.

Urban logistics is a kind of **medium-level logistics**, which is between macro-logistics and micro-logistics. It can be regarded as a transition from micro-logistics of many companies to macro-logistics between cities (Taniguchi, E., 2014). The macro logistics input into the city is dispersed into thousands of micro-logistics through urban logistics; The micro-logistics exported by thousands of enterprises must be integrated into the macro-logistics through urban logistics. Compared with the industry logistics which is also medium-level logistics, the main difference is about **research objects and pursuit goals**. Urban logistics research **targets all logistics activities within the city**, while industry logistics focus only on a single industry. The pursuit of industry logistics is to maximize the benefits of the industry. In the process of pursuing, it is inevitable to sacrifice the interests of other industries or social interests, which would impact society, environment, transportation, etc (Rosenfield, D. B., Shapiro, R. D., & Bohn, R. E., 1985). The goal pursued by urban logistics is to minimize the cost of the entire city, including environmental, social, economic, and transportation factors.

1.3 literature review

In recent decades, urban logistics has received more and more attention in academic and practicle production fields. Different roles in the city have spent a lot of energy on the study of urban logistics strategies and development methods. Due to the various influencing factors of urban logistics, the research topics and methods are fragmented. In order to clarify the research context for many years and find the structural pillars of research development, Alexandra, Roberto, & Ruggero (2016) made systematic literature review and main path analysis, by reviewing 104 academic papers on urban logistics research, the evolution path and three most potential research areas in urban logistics were detected, which are **stakeholder involvement, urban logistics ecosystem, and data sharing platforms**. Dolati Neghabadi et al., 2018, summed up six major research fields of urban logistics in recent years through a systematic literature review on 370 papers, which are **definition&perimeters, policy, innovative solutions, sustainability, methods and stakeholders**. All the research topics can be devided into two categories, **namely solutions for urban logistics problems and implementation of the solutions.**

1.3.1 Research evolution

Research on logistics began in the United States in the 1950s and developed in Japan. Europe is also one of the early places to introduce the concept of "logistics", and it is also a pioneer in applying modern technology to logistics management. In recent years, developed countries have fully recognized the importance of the logistics industry and urban logistics. Governments have adopted a series of macro policies to vigorously support the development of logistics industry. Many countries have proposed development plan of building large-scale cities as global freight hubs. The logistics industry is also becoming more and more important in the entire national economy of developed countries. Enterprises are paying increasing attention to logistics, and the third-party logistics is rapidly developing. According to relevant statistics, the volume of the US logistics industry is almost twice that of high-tech industries, accounting for more than 10% of US GDP (Aoyama, Y., & Ratick, S. J. 2007). In Europe, it is widely believed that the third-party logistics market has a certain maturity. As early as 2006, the proportion of third-party logistics services in Europe has reached 76%, and in United States it is about 58%. At the same time, about 24% in Europe and about 33% in United States are actively considering the use of third-party logistics services. Japan's third-party logistics accounts for 80% of the entire logistics market, and its social distribution between domestic enterprises and third-party logistics companies is leading the world(Lieb, R. C., & Lieb, K. J., 2015).

The concept of “logistics” was introduced to China from Japan in the 1990s. The development of logistics in China has experienced a long and tortuous process. It used to be planned economic system in China. The government implements mandatory allocation and supply of various commodities, especially production materials. The main task of logistics is to ensure the completion of the national mandatory plan. The main contents are transportation, warehousing and distribution. Since “the reform and opening up”, especially since China joined WTO, the importance of the market mechanism has gradually emerged, and logistics has got a new connotation. In recent years, the central government and local governments have greatly increased their emphasis on the development of the logistics industry, greatly improved the investment in transportation infrastructure related to the logistics industry, vigorously supported the development of third-party logistics enterprises, and actively promoted development of logistics information platform and new technology equipment. At present, China has become a major logistics country, with global influence on logistics market. Freight volume of railway, highway and waterway, cargo turnover, throughput of port and container, and express delivery are all occupying the front rank in the world (Jiang, B., & Prater, E., 2002; Goh, M., & Ling, C., 2003; Liu, J., 2018).

1.3.2 Typical strategy proposed

The research of urban logistics solutions focuses on two major themes, **1) how to reduce the cost of freight within the city. 2) how to reduce the adverse impact of freight on the environment.**

Taniguchi and Heijden, (2000) proposed **a method for quantitative analysis** of urban logistics initiatives. The modeling results show that **advanced routing and scheduling systems, cooperative freight transport systems and load factor controls** can effectively reduce the total cost of freight operations and CO2 emission. Ambrosini and Routhier, (2004) **analyzes and compares the different objectives, methods and indicative results** of urban logistics in nine industrialized countries in Europe, America and Asia. Through the comparison between different countries, the article summarizes the main factors that promote the sustainable development of urban logistics. It is pointed out that due to the different characteristics of cities in different countries and regions, a concrete analysis of specific situations is needed, **emphasizing the importance of case study** for feasible method research. However, **the lack of quantitative analysis methods weakens the objectivity** of the comparison of different measures. Anderson, S., Allen, J., & Browne, M. (2005) discussed the advantages and disadvantages of urban freight transport to the city's economic vitality and sustainable urban development. Through the **case study of seven different companies** in three UK urban areas, it **analyzes the operational, financial and environmental impact of the four measures** on these companies.

At this stage, the study of urban logistics has extensively analyzed the effective measures of urban logistics. Through various qualitative and quantitative methods, **the effects of different measures are verified**. However, **most of the early urban freight measures failed**, because the research at this stage only focused on the **one-sided background environment**, and **did not fully consider**

dynamic impact between logistics measures and other aspects of the city, and **did not consider all the stakeholders** in logistics (Macharis & Melo, 2011). Therefore, the later literatures also turned to focus on **how to effectively implement the logistics strategy**. In the meantime, it can be seen that **comprehensive modeling is very necessary**, which is helpful to make the proposed scheme more executable.

1.3.3 Effective implementation of strategies

In the context of the continuous implementation of urban logistics measures and the continuous failure, many research institutions have realized that **one of the main factors that can effectively implement urban freight solutions is cooperation among stakeholders** (Hensher and Puckett, 2005; Holguín -Veras, 2008). There are many stakeholders in urban logistics, including **cargo owners, logistics providers, urban residents, government authorities, environmental protection departments, etc**. Different stakeholders have different goals and interests, so the cooperation between the parties is complicated. For instance, HolguínVeras (2008) proposed that, it is not possible to achieve off-hour distribution by collecting peak tolls, because the delivery time is usually **determined by both the carrier and the receiver**. The receivers are not sensitive to the toll, and the off-hour distribution will increase the cost of other aspects, so the receivers usually disagree. Stathopoulos et al., 2012 did a case study in Rome that examined the different responses and acceptances of different stakeholders in the city to the same policy and **analyzed the views of different stakeholders**. Ballantyne et al., (2013) analyzed the situation in different countries, especially Sweden, the United Kingdom and the Baltic region, and found that **local authorities still do not have a good understanding of urban logistics issues** because they **do not have a flexible method to simultaneously consider the conflicting interest of stakeholders** and the complexity of different solutions.

Later, different organizations have made various attempts to **find such a comprehensive evaluation method**. Macharis et al., 2014, adopted the **multi-actor multi-criteria analysis method** proposed by Macharis, 2005, Macharis, 2007, combined with the particularity of urban logistics. Using the city distribution multi-actor multi-criteria analysis (CD-MAMCA) methodology, a case study of Kuehne and Nagel was adopted to study the effectiveness of real-time remote monitoring of goods to improve cargo tracking and warehouse management. Bjerkan et al., 2014 also **emphasized the importance of stakeholder acceptance for the effective implementation** of urban logistics solutions. The stakeholders' acceptance of the two specific measures, which are increasing urban street utilization and night delivery, was evaluated. The facilitators and obstacles of the two measures are analyzed, and a theoretical representation framework of the urban logistics cooperation process and **a method to measure implementation** of policies are proposed. Lindawati et al., 2014, explored Singapore's urban logistics and **analyzed the motivations and barriers of cooperation among urban logistics stakeholders.** The analysis shows that the expected benifit is the motivation of the industry participants, while the competitive intelligence risk is the hindrance of the participants' decision. Gatta and Marcucci (2014) recommend the use of **an agent-specific approach**, which takes into account the specific characteristics of each stakeholder and might increase decision makers' awareness and help taking better decisions. In the face of frequent failures of European urban projects, Gammelgaard, 2015, taking the example of urban logistics in Copenhagen, used qualitative process analysis to study urban logistics emergency and explore whether it can be managed.

It can be seen from the literatures that after the academic circle turns to the validity of logistics strategies implementation, it has played a very good effect in the formulation of the logistics strategies. It also proves that more comprehensive problem analysis and data processing can significantly imporve the effectiveness of logistics strategies.

1.3.4 Literature reflect

Until now, there has been no unified conclusion in the field of urban logistics research, indicating which methods can fully take into account the complexity of the solution and the game relationship between different stakeholders. The exploration of this topic by a large number of research institutions is still ongoing, and this field is in constant assumptions and trial and error.

According to the literatures mentioned above, the problems with logistics are not only about how to simply lower down freight cost and reduce adverse environment impact. There are **deeper and more realistic evaluation criteria**, such as **the driving effect of logistics on economy**, **the development of logistics enterprises** and **the improvement of urban competitiveness**. These more realistic questions require further investigation. Furthermore, because of the comprehensiveness and complexity of urban logistics, it is necessary to put forward a more comprehensive modeling and simulation method and discuss the effectiveness of implementation measures.

1.4 Research method and content

In this paper, the effectiveness of urban logistics policy is discussed under the following aspects of consideration. **Firstly**, in the study of urban logistics problems, the particularity of different cities should be fully considered. Therefore, **the case study method** is adopted in this paper. The specific data of Chongqing is investigated, in order to get more targeted countermeasures. **Secondly**, the combination of qualitative and quantitative research methods and more comprehensive modeling and simulation means should be adopted. **The systematical approach and system dynamics model** are used in this paper, substituting the real historical data of Chongqing, to support the theoretical analysis through model simulation. **Thirdly**, the influence of urban logistics on economy, enterprises and city competitiveness should be considered comprehensively. The effect of multiple participants on the implementation of strategies should be fully considered. Thus, **a giant system model in the fields of logistics, economy, society and transportation** is constructed in this paper. The evaluation indexes of economy, enterprise and city competitiveness are put forward. The different roles of the participants are fully analyzed in the model. The feedback and comprehensive influence of multiple participants is reflected by the system dynamics model.

1.4.1 Research method

Combination of qualitative and quantitative methods is conducted in this study, the specific research methods are as follows:

1) Case study method

2) Systematical approach

3) System dynamics modeling

System dynamics takes qualitative analysis as the guide and quantitative analysis as the support. The two aspects are unified and complement each other. The system dynamics model is established, starting with the internal operating mechanism and microstructure of the system. With the help of computer simulation, the internal interaction relationship of the system and the influence on the behavior of the whole system are analyzed. In this way to explore the solution to problems.

1.4.2 Research question

In this paper, the urban logistics system is taken as the research object, and the case of Chongqing in the central and western regions of China is taken as an example. **Sustainable development strategy of urban logistics system** is explored based on the city's economic, social, transportation and environmental background, guided by government departmental policies and regulations. For a suitable and practicable strategy, it is necessary to prevent the waste of resources in the rapid development of the logistics industry, as well as to prevent its slow development not catching up with economic and social needs, thus hinder the healthy development of the urban economy.

As so, the research question is, **how can we propose effective development strategies to promote the sustainable development of logistics in Chongqing and ensure the optimal results of the entire system**?

Under this question, sub-questions are proposed as follow.

Sub-question 1. Summarizing the internal structure of urban logistics, what are the evaluation indexes of urban logistics development?

Sub-question 2. Based on systematical analysis, what are the main challenges of Chongqing's logistics industry development?

Sub-question 3. Given the synthetically consideration of sustainable development and optimization of urban system, how would be the implementation effect of the policies?

1.4.3 Research content

Based on the research questions and methods mentioned above, the structure of this paper is designed as follows:

Firstly, the relationship between urban logistics system composition and internal supply and demand is summarized, based on domestic and international research status with related theoretical results, and the interaction between urban logistics and other aspects of the city is analyzed, while the overall structure relationship diagram of logistics system including key external influence factors is established. **Then**, the development characteristics and existing problems of logistics system in the case city of Chongqing is analyzed. **Furthermore**, the SD model of urban logistics system is set up, and the model parameters and structure are configured according to the corresponding strategy. The effect of policies will be simulated and predicted. The main research contents are as followed.

Chapter 1 Introduction. It introduces the research background, the existing research foundation and the research content of this paper.

Chapter 2 Theoretical analysis. The sepecial demand for research method, the characteristics and particularity of research problems and the current status and challenges are analyzed systematically. Research objective and case selection are put forward.

Chapter 3 Logistics structure and objective analysis. The composition of urban modern logistics system is analyzed, together with the interaction between urban logistics and other aspects of urban. The evaluation standards of urban logistics system are proposed.

Chapter 4 Current situation and challenge of Chongqing logistics. In order to understand the logistics situation of Chongqing, material elements, stakeholders, environmental elements and logistics public policies are analyzed. Problems existing in the development of modern logistics in Chongqing are comprehensively analyzed.

Chapter 5 SD model and policy analysis. SD model are constructed and the validity of the model is tested. Based on the simulation results, the effect of policy is predicted and analyzed.

2. Theoretical Analysis

2.1 Systematical approach

The **logistics process is an organic part of the economic and social system**. It has diversified external connections and multi-level internal structures. To understand and grasp the development law of urban logistics, we cannot adopt isolated and static analysis methods, **but should take systematical and comprehensive analysis method**. A **common type of systematical approach** is shown in Figure 1, including defining problems, conducting surveys, setting goals, objectives and criteria, designing alternatives, predicting and evaluating the performance of alternatives, implementing an alternative and reviewing the performance of the system.

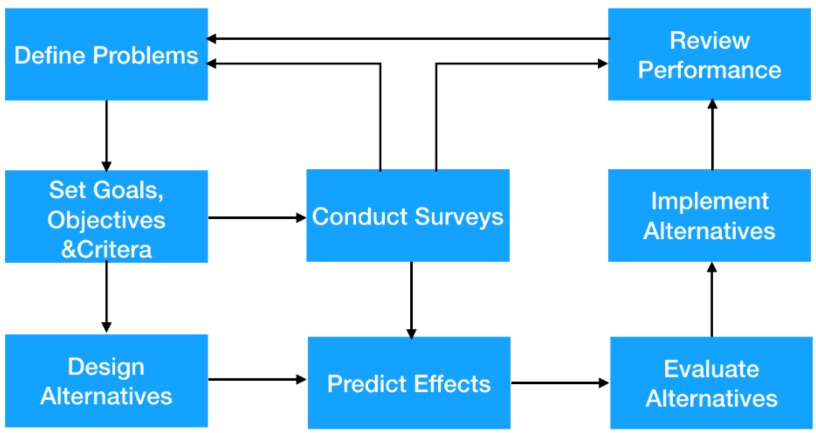


Figure 1 A system approach framework

In this classical system approach as shown, **the first step** is to define the problem and perform the corresponding investigation. **The second step** is to set the target and the evaluation system for the investigated problem. **The next three steps** are to design the alternatives, predict the effect of the measure, and evaluate the relevant measures. **Finally**, select the best evaluation measures and design the implementation plan for it. In a complete system approach, the actual results after the implementation of the measures should also be included, together with repeating the process after the actual policy implementation, so as to dynamically adjust the strategy according to the actual situation.

In this paper, given to the research problems and actual conditions, the above approach **has been made adjustment**, and the adjusted system approach block diagram is shown in Figure 2. After the adjustment, **the first step** "defining the problem" is to first define the research question, make the background analysis and research objectives. Understand the internal structure of the urban logistics, the component elements, and the interaction between the elements while a full investigation of Chongqing city's actual situation is indispensable, based on which **the crux and challenges** will be found**. The second step** is to set the target and evaluation criteria, that is, to set the long-term and short-term goals of the development of the logistics industry in Chongqing. Only the clear target evaluation mechanism can correctly guide the later planning. **Next three steps** are based on urban logistics framework structure and the relationship between the various environment elements in the first step, which are "**design strategies**", "**predict effect"**, and "**evaluate alternatives**". Finally, the implementation of the strategies should be analyzed.

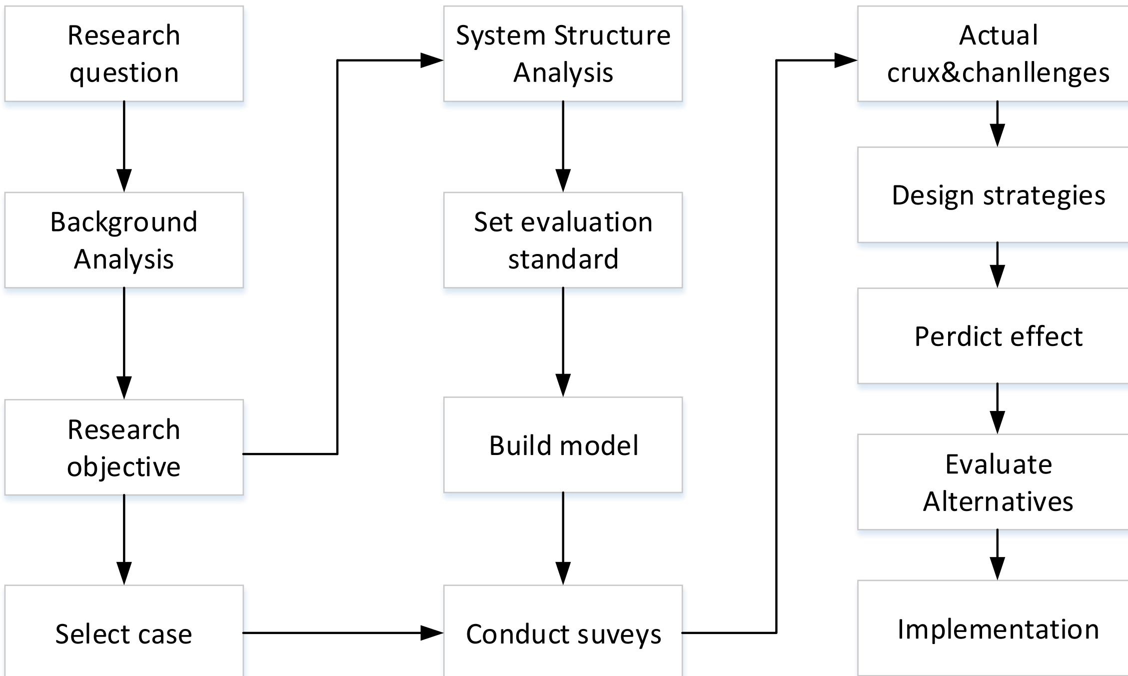


Figure 2 Adjusted system approach framework

To adjust and control various factors in the logistics system, it is necessary to understand the relationship between different parts of the system, and make correct abstraction and description of the system. There are many ways to **describe the motion process of a system**, both qualitative and quantitative. **This paper combines qualitative analysis with quantitative analysis**, using **system dynamics modeling and simulation methods** for a better prediction, in order to provide a **more powerful support for predictive effects and evaluate alternatives**. This topic selects Chongqing, a mega city in China's central and western regions, as a case study. From abstraction to details, effective development strategies for Chongqing modern logistics system are proposed through the quantitative analysis of indicators, based on the research of urban logistics system framework.

2.2 Particularity analysis

Urban logistics mainly has three particular aspects.

First is the high density of logistics. Logistics density refers to the number of logistics business, facilities, equipment, and organizations owned by the unit area (Hensher, D. A., & Puckett, S. 2004). Compared with suburban, rural or interurban area, logistics elements in urban area are relatively concentrated. Therefore, urban logistics density is relatively high, especially in large cities. Higher logistics density leads to more serious problems and is fraught with hidden danger. Hence, urban logistics organization and management are required to be more scientific, systematic and rigorous, which lead to much more difficulties.

Second is that there are more constrains. Urban area is not only the center of production, circulate and consumption, but also the center of politics, economy and culture. Limited urban space has to be divided into manufacturing and living regions, including transportation, tourism, cultural, business, sports, education, medical zones (Quak, H. 2011). Moreover, urban area has highly crowded massive people with high mobility. However, any other land use plan and people mobility are sort of obstacle for urban logistics. The layout of logistics network, the planning of logistics routes and the development of logistics business would be affected and restricted by these "obstacles". Apparently, there is much less "obstacles" and restrictive factors in rural area and the difficulty of organization and management is not as great as in urban area.

Third is that urban logistics is mainly based on short distance road logistics. Theoretically speaking, urban logistics includes urban input and output freight (artery logistics) and urban internal freight (Lagorio, A., Pinto, R., & Golini, R., 2016). Input and output logistics refers to the freight from the outside of the city into the city and from the inside of the city as a starting point to the outside of the city. The starting or ending points of urban input and output logistics are mainly stations, ports, airports and other logistics nodes. Urban internal logistics refers to the same-city logistics that occurs among logistics nodes and different users. Since urban logistics does not consider the long-distance transportation of goods between cities, it mainly depends on highway and trucks. The most prominent feature of urban logistics is that highway logistics takes majority part of it, especially the short-distance highway logistics (Hesse, M., 2016). Therefore, the biggest problem of urban logistics is the external diseconomy of highway logistics, mainly traffic congestion and environmental degradation.

2.3 Context analysis

2.3.1 Current status

The logistics industry is a giant whose volume is larger than many other businesses. In 2017, China's total social logistics volume was 252.8 trillion yuan, with 6.7% year-on-year growth. From the perspective of the whole society logistics composition, the industrial logistics volume is 234.5 trillion yuan, accounting for the largest proportion. Import and export logistics ranked second, which is 12.5 trillion yuan. The specific proportion of various types of logistics is shown in Figure 3. Even the smallest composition, the resident logistics, has exceeded 1 thrillion yuan. It can be seen that the Chinese logistics market is very huge.

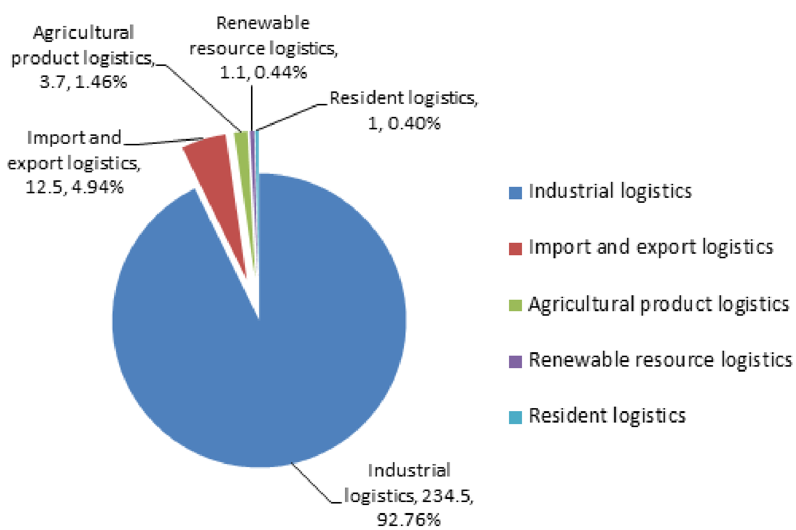


Figure 3 Logistics segment market proportion in 2017

In 2017, the total cost of social logistics was 12.1 trillion yuan, with 9.2% year-on-year growth. Comparing to that the total revenue of logistics industry was only 8.8 trillion yuan, which was increased by 11.5% (Data sources: CFLP). Data show that logistics cost is relatively high in China. From the perspective of the cost composition of logistics, transportation costs accounted for a maximum of 6.6 trillion yuan, while storage costing of 3.9 trillion yuan and management costing of 1.6 trillion yuan, as shown in Figure 4.

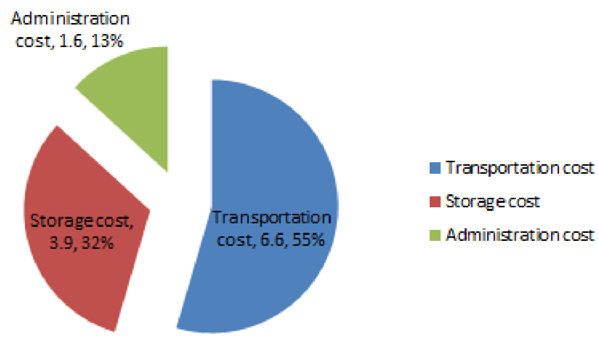


Figure 4 Composition of logistics cost in 2017

The ratio of logistics cost to GDP is an important indicator, known as the economy-logistics index, which is commonly used internationally to measure the level of logistics development in a country. According to Figure 5, the statistics of China and the United States from 2010 to 2017 shows that logistics costs in China account for a relatively high proportion of GDP. At the same time, industrial structure is constantly optimized and efficiency is gradually enhanced, which makes the proportion of logistics costs decline for a long time. However, compared with the United States, China still has a gap of more than 7%. Given the market value of the total logistics cost, which is 12.1 trillion yuan, for every 1% decline in the cost ratio, the corresponding market value will be hundreds of billions.

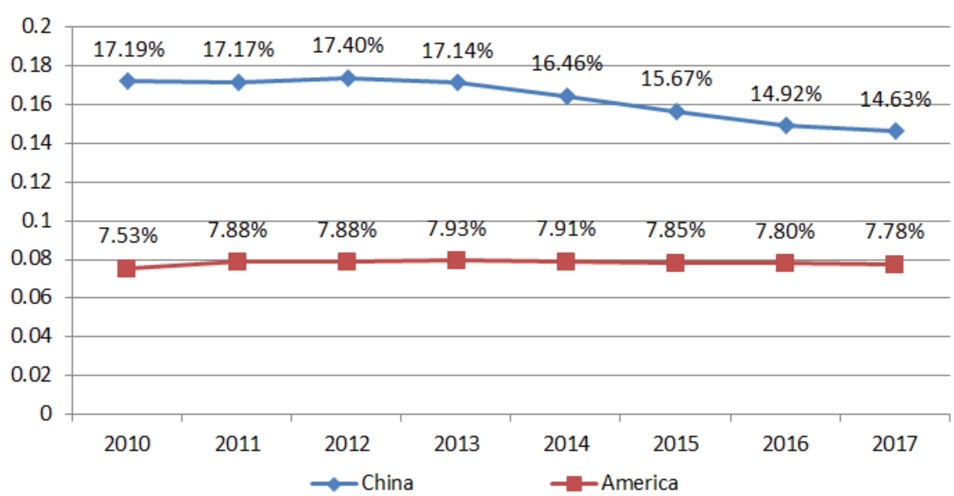


Figure 5 Logistics costs as a share of norminal GDP in the US&China (2010-2017)

Transportation, storage, and logistics platforms are three key points of urban logistics.

Currently, in China's transportation industry, the road transport market is relatively dispersed. There are many different companies in the field of each market segment, such as vehicle logistics, LTL(Less-than-carload Logistics), express delivery and city distribution, with no obvious industry leader. Meanwhile, railway, waterway, pipeline and civil aviation transportation markets are mainly controlled by a few state-owned backbone enterprises, such as China Railway Materials Company, China Shipping Company, China Ocean Shipping Corporation, China National Petroleum Corporation and several major civil aviation companies (TalkingData, 2017). For the urban logistics, since it's mainly based on road logistics, it has to face the dispersed and messy transportation market.

In the field of storage, enterprises can be divided into three major types, including estate, warehouse, and equipment (together with equipment manufacturing). Due to the rapid development of recent decade, China's commercial general-purpose warehouse area achieves nearly 1 billion m^2, of which 3-D warehouses accounts for nearly 30%. Overall, the warehouse facilities have basically met the logistics needs, but there are still some contradictions between supply and demand on the structure and regional distribution. The shortage and the oversupply of warehouses, the high vacancy rate and high rent, the rapid construction of warehouses and the decline in warehousing efficiency all exist simultaneously, especially in less developed cities in China.

The logistics platform contains the management platform and the information platform. Among them, the typical third-party/four-party management platforms are Rookie Logistics and oTMS. They seamlessly interconnect shippers, third-party logistics companies, transportation companies, drivers and consignees, forming a balanced logistics ecosystem based on core processes. Jingdong, Yunda, Shunfeng, Shentong and other express delivery companies take mostly first/second party management modes. But they are basiclly in e-commerce and express delivery. For the industrial logistics and bulk commodity logistics, the management and information platform are relatively backward. Thus, for the industrial cities, there is a shortage of logistics platforms.

2.3.2 Spatial distribution characteristics

The differences of development level between China regional logistics are huge, while the distribution of logistics development in various provinces and areas is uneven. It can be concluded that the spatial distribution of regional logistics development level in China has the following characteristics, based on the evaluation of the 2015 provincial-level administrative district logistics development level index (Huiming, Z., 2015):

1) The developed level of regional logistics development generally shows a decreasing trend from the coastal to the inland. The eastern coastal areas have superior location conditions with well-developed social economic foundations, and are at the forefront of the Reform and Opening-Up, enjoying early policies and dividends from the reform, thus all aspects of social development are relatively fast and achieves a high level, so as to the logistics development. In fact, high-level and medium-level logistics industries are mainly distributed in the eastern coastal areas. In the central and western regions, however, due to its historical development and relatively inferior location conditions, the development of social economy and other aspects are lagging behind, which also leads to a large gap between the level of local logistics development and that of eastern region.

2) The high-level regional logistics development area generally presents a "T" shape layout feature. As shown above, the high-level logistics areas are mainly distributed in the eastern coastal areas, showing an obvious "point-axis" distribution pattern. The eastern coastal region has formed an important axis for the development of China's logistics industry. From the northeastern province Liaoning to the southern province Guangdong, this axis constitutes an important activity belt for China economic development and foreign trade. The medium-level logistics areas are mainly distributed along the Yangtze River, forming an important logistics corridor, with the downstream

Shanghai as the leader, Hubei and Chongqing in the middle and upper become important logistics nodes. A large city group are located on this “T” shaped axis, which are the growth poles of China economic development, and are also as gathering places for logistics.

Overall, logistics in the eastern coastal areas has developed strongly and has gradually spread to the Midwest. The logistics in the central region is at a medium level, but its development is relatively balanced. The logistics in the western region is at a low level, with a vast difference among the provinces, where Shaanxi, Sichuan, and Chongqing are the leaders. From the aspect of space, the logistics expansion capacity is bulging along the Yangtze River, and there are three obvious development steps, with Shanghai as the leader. The first echelon is within the downstream of Yangtze River, mainly consist of Shanghai, Jiangsu and Zhejiang, with a highest logistics development level and space expansion ability. The second echelon is within the midstream of the Yangtze River, represented by Anhui, Hunan and Hubei. The third echelon is the within the upstream of the Yangtze River, represented by Chongqing and Sichuan, with a low logistics development level and space expansion capability.

A healthy development of the logistics industry and a rational layout of logistics facilities will do great help to urban spatial structure and function optimization, of which reason the logistics development policy research has been carried out a lot. But compared with the eastern coastal areas, the logistics development in the western region is obviously backward and slow, whose logistics research is relatively less. With the background of globalization, the expansion of inter-regional openness and international openness of western China is inevitably required. Especially after the One Belt and One Road strategy is proposed in China, the western region has changed from the endian of opening up to the frontier, and has become an important part of economic globalization. Consequently, its logistics development is receiving more public attention.

2.3.3 Problems summary

China's logistics industry has developed rapidly to a large scale, but its performance is not satisfactory. In China's transforming process from traditional warehousing to modern logistics industry, there are still problems. **Firstly**, the distribution of urban transportation infrastructure is uneven. For example, in many central and western cities of China, transportation capacity still cannot meet the growth demand, which seriously affects logistics efficiency(Debao, D.,&Tijun, F.,&Qi, A., 2018). **Secondly**, unified organization and management of transportation tools within the city is insufficient. The ratios of repeated and one-way transportation are high, which increases the city traffic load, and leads to a widespread urban congestion together with a increased noise and other pollution(Zhao, X., Flynn, B. B., & Roth, A. V., 2007). **Thirdly**, the continuous logistics process is artificially separated into many segments and every segment belongs to a different department, which do not share information to others, and this phenomenon affects the urban logistics efficiency (Liming, H., 2018). **Forthly**, the third-party logistics market is still not mature enough. Although the traditional warehousing and transportation enterprises have been equipped with sufficient facilities, the needs of modern logistics are still not being met, due to the low utilization rate of facilities, technical level, information degree, innovation, and operational efficiency. Although many production enterprises or commercial enterprises want to outsource their business, they cannot find a suitable service provider, and cannot establish trust in logistics enterprises, due to the limitations of logistics enterprises service capabilities, which make the proportion of third-party logistics services still low. Therefore, production companies or commercial enterprises choose to invest a lot of money to build their own logistics network, resulting redundant construction and a waste of logistics resource (Zhitai, W., 2018). In addition, there are alse problems with the quality of logistics service. There are many logistics links and the information is not transparent enough, which makes it difficult to guarantee the safety of goods, and it is also difficult to trace the responsible party when something goes wrong.

2.4 Research objective & case selection

The urban logistics system was chosen as the research object, with the target of **solving the problems existing in the modern urban logistics system of Chinese cities**, in order to **further enhance the development level of the logistics industry**, promote the **sustainable development of the city**, and **provide a scientific planning route**. In order to make the analysis more specific and clear, the paper selected Chongqing urban logistics as an analysis case.

From a national perspective, on the one hand, Chongqing is located in the central and western regions of China, which has long been ranked as a second-tier city in China, and was just rated as a new first-tier city in 2017. Different from the post-industrialization stage of China established first-tier cities, Chongqing industrial structure is facing a transition from the secondary industry to the tertiary industry, and has experienced in the process of rapid industrialization. Thus, **taking Chongqing as a case can serve as a reference for the development of other second-tier and third-tier cities in China**, and also stands for cities in the western region where China logistics industry is relatively backward. On the other hand, among the 12 provincial capital cities in western China, Chongqing is the most logistics-competitive city in the west (Huiming, Z., 2017). Chongqing has strong economic power, strong industrial base and huge population scale, where industrial support, consumption security and human resources support can be provided for logistics industry development, and higher requirements for logistics are also raised. Chongqing has the comprehensive traffic conditions and can develop into a nationwide integrated logistics hub. Therefore, the research on the development strategy of Chongqing logistics system has important practical meaning for the development of the western region of China, as well as to the national T-shaped strategy, and the One Belt and One Road strategy. From the internal aspect, Chongqing integrates big cities, large rural areas, large mountainous areas, and large inventory, due to which situation the economic development is very uneven, and the internal traffic conditions are complex. How to take advantages of logistics industry in the process of rapid industrialization, is an important topic in Chongqing, which will also be answered in this thesis.

3 Logistics Structure and Objective Analysis

According to the definition of urban logistics, which refers to the physical flow of goods within the city, the distribution of goods in urban and external areas, and the process of urban waste cleaning, it can be seen that the logistics system is very complicated, and contains many operational elements， supported by environmental factors. To study the development strategy of urban modern logistics system, we must first define the composition mechanism and role relationship of logistics system. According to the analysis of system components and participants, the framework of urban modern logistics system is defined and shown in Figure 6. The block diagram shows the interaction between the various components of the logistics system. Based on the urban logistics service platform, the urban logistics supply capacity is in line with the demand characteristics, realizing the dynamic balance of the logistics market. The logistics market interacts with the city economic, social, transportation, and ecological environment, which is regulated and guaranteed by policies and regulations.

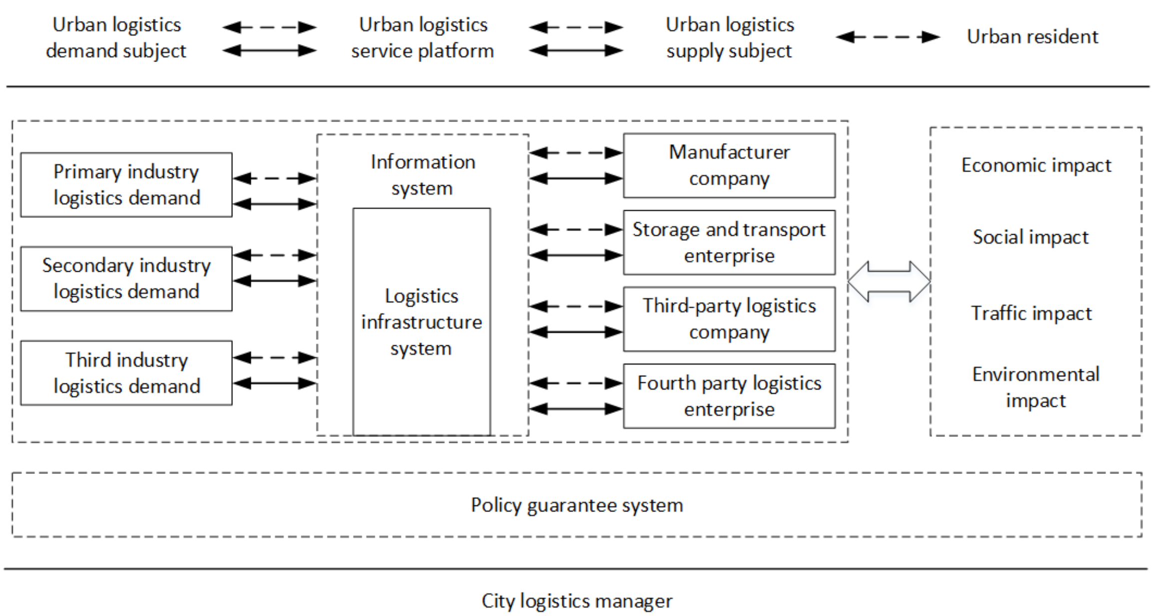


Figure 6 Framework of Urban Logistics System

The elements in Figure 6 can be classified into material basic elements (including infrastructure, logistics information system), participating elements (including demand subject, supply subject, local government, and city residents), and environmental elements(including economic, social, ecologic, and traffic factors), described as followed.

3.1 Material basic elements

The establishment and operation of the logistics system requires a large number of technical equipment and support facilities. Because the organic connection between these means and the facilities is decisive for the operation of the logistics system, so we classify them as the basic elements of materials. These elements are essential to achieving logistics functions, including logistics infrastructure and logistics information systems.

3.1.1 Logistics Infrastructure

Logistics infrastructure refers to the channels, nodes, equipment and tools required for cargo storage, logistics handling, handling, carry, transportation and other activities. The categories of urban logistics system infrastructure is shown in Table 1.

The channels between the nodes are the places where the physical logistics activities are carried out. Among them, the activities carried out in the channels are mainly transportation, including trunk transportation, distribution and transportation. Other activities in the logistics system, such as packaging, loading and unloading, storage, etc., are done in the nodes. The logistics channel is the most basic logistics element, including railway, waterway, aviation routes, highways, urban trunk roads, and branch roads, while the logistics node is the nodule of the logistics network connecting the logistics channels. Logistics nodes include large-scale logistics cargo distribution centers such as logistics parks, distribution centers, terminals, air freight stations, and freight stations. It can also be a short-term stop for distribution terminals such as wholesale markets, factories, community service stations, and parking spots in commercial centers. These facilities are also essential material elements of urban logistics, and their capacity directly affects the urban logistics supply capacity. For the urban logistics system, the most important issue is the spatial layout of urban logistics facilities and outlets, which directly affects the efficiency of urban logistics and the overall traffic conditions of the city, and thus affects the lives of residents.

Logistics equipment and tools mainly refer to equipment and tools for transportation, storage, handling, and transportation, including transportation vehicles, containers, pallets, shelves, conveyor belts, forklifts, etc. From multiple considerations of urban logistics standardization and urban transportation environment, cargo vehicles are given the requirements of flexibility, speed, safety, efficiency, low cost and environmental protection. Many cities have made specific regulations and requirements for urban distribution vehicles, including types, appearance, safety, and environmental protection, which gradually forms standard while the diversity is maintained. Demands for trucks professionalism are also proposed. Intelligent transportation, unmanned handling vehicles, robotic stacking, unmanned forklifts, automatic sorting and sorting systems, paperless office systems, modular technology, simulation technology and other modern logistics technologies will further improve logistics mechanization, automation and intelligence level. The processing capacity of logistics equipment for goods reflects the efficiency of logistics supply services, and is a tool for completing urban logistics activities such as packaging, warehousing, loading and unloading, and circulation processing. The development direction of logistics equipment is automation, scale and information. In recent years, the utilization of information technology has fundamentally improved the efficiency of logistics equipment.

Table 1 Urban logistics infrastructure categories

Infrastructure	Categories	Example
Logistics Channel	Transportation Network Line	Highway, waterway, railway, urban main road
	Distribution Line	Urban main line, branch, other road, industrial and mining enterprises dedicated roads
Logistics Node	Large Cargo Distribution Center	Logistics park, delivery center, pier, air station

	Distribution Terminal Stop	Wholesale market, factory, business center, supermarket, parking stop
Equipment and tools	Transportation Equipment	Transport vehicle, container, transportation pallet
	Storage Equipment	Shell, stacker, van, sorting equipment
	Handling	Crane, forklift, conveyor, shuttle bus

3.1.2 Logistics information system

The modern logistics system is a complex, large and dynamic system. It is not only complex in form and performance, but also complicated in operation, including storage, movement, exchange, sorting, packaging, grouping, splitting, and selecting. As a result, the information system of modern logistics is also complex, open, and diverse. In the logistics information system, there are both information flow and capital flow, as well as business exchanges information which involves intelligent technologies.

The application of modern logistics information system in logistics operations, logistics equipment, logistics and transportation deployment, etc., has accelerated the order processing capability, shortened the average transportation distance of goods transportation, reduced the amount of inventory, and greatly shortened the physical operation cycle. With the help of the information system, the logistics efficiency has been significantly improved, which is critical to the realization of the overall optimization objectives of the urban logistics system.

From the aspect of composition, the logistics information system consists of software and hardware. The software includes information system software for warehousing and transportation, as well as cargo vehicle management system and customs declaration system. The hardware refers to carriers that support the operation of each software system.

From the aspect of system participants, the logistics information platform is a large network system formed by the macro management, department management, and logistics enterprise layers involved in the logistics process through the network platform (Liu Langui, 2018).

From the aspect of technique, the logistics information system includes emerging intelligent technologies, such as intelligent computing technology, cloud computing technology, data mining technology, and expert system technology.

3.2 Participating subject elements

The operation of the logistics system relies on the joint role of the multi-participants. The participants can be divided into four categories, including logistics demand subjects, logistics supply entities, local government departments, and urban residents. The logistics participating subjects interact with each other, and the interaction of their behavior is shown in Figure 7.

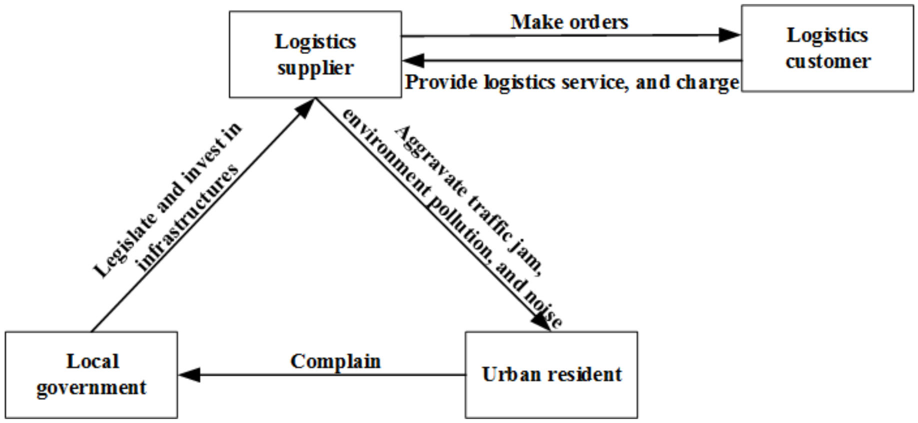


Figure 7 Stakeholders of urban logistics system and their relationships

3.2.1 Demand subject

The logistics demand subject is the owner of the goods, including variant forms of sender and receptor pairs, such as suppliers and wholesalers, suppliers and retailers, wholesalers and retailers, retailers and final consumers, and even supplier and final consumers, as shown in Figure 8. Urban logistics includes all the circulation processes from the different forms of senders and receptors, together with the scheduling and management during the circulation process. These suppliers, wholesalers, retailers and consumers are the main demand entities in the logistics system. Their goal is to pay for a lower transportation expense while delivering goods safely, quickly and accurately.

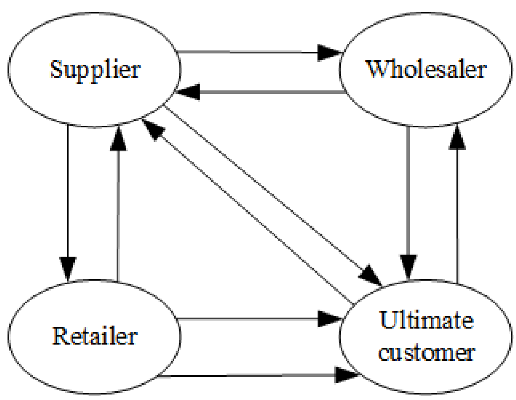


Figure 8 Structural relationship of logistics demand subjects

3.2.2 Supply subject

The logistics supply subject is the provider of logistics services. The goal of the logistics supply subject is to maximize the self-profit, minimize the logistics cost, and also ensure the goods owner requirements for logistics timeliness. There are two main types of urban logistics supply entities. One is a professional third-party or fourth-party logistics enterprise, and the other is a corporate logistics entity or a self-operated logistics enterprise, as shown in Table 2. (Hong. X, 2013).

Table 2 Stratified comparison of logistics supply subject (Hong, X, 2013)

Primary factor	Secondary element	Tertiary element	Four-level element
Logistics Service Supply Subject	Corporate logistics	self-operated corporate logistics	Industrial corporate, Circulation corporate
		partial self-operated corporate logistics	
	Third/fourth -party logistics enterprise	Universal service logistics enterprise	Transportation company, warehousing enterprise, express delivery company, shipping agent
		Professional supporting logistics enterprise	Car logistics, electronic logistics

Different logistics supply subjects, combined with different logistics operation modes, constitute the current complex logistics supply environment. The logistics operation mode includes complete self-operation, partial outsourcing, logistics system divestiture, logistics strategic alliance, complete outsourcing, and logistics system takeover. At present, the international evaluation level of logistics service is mostly based on third-party logistics (3PL), and China's 3PL accounts for only 17% of total logistics, while logistics developed countries accounts for 30% (Zhang Wei, 2018).

3.2.3 Local government departments

The government departments are the authoritative organizations for formulating and implementing laws and regulations, setting long-term development plans for the development of urban logistics, optimizing the urban logistics development environment, creating a good platform for urban logistics operations, leading the construction of urban logistics public information platforms, and coordinating each Stakeholders. Its purpose is to support the development of the local logistics industry, promote urban economic development, and ensure employment, while minimizing the side effects of logistics activities to the urban environment and transportation, and creating an efficient and ordered urban logistics operation environment.

3.2.4 City residents

The residents of the city share the roads together with the logistics activities, to jointly bear the impact of traffic congestion and deterioration of the ecological environment. At the same time, urban residents are also the ultimate consumers of logistics products. Its purpose is to achieve lower prices and a good living environment with smooth traffic.

3.3 Environmental elements

The urban logistics system is an open and dynamic complex system, being one of the important subsystems of urban economic and social development. As a result, the urban logistics industry is intertwined with the urban economy, society, ecological environment, and urban transportation, which has produced various problems of urban development, and is also affected by the reverse effect of urban development, as shown in Figure 9. Therefore, when studying urban modern logistics system, the role and influence of environmental elements including economic, social, ecological, and transportation factors cannot be ignored (Xiao Hong, 2013).

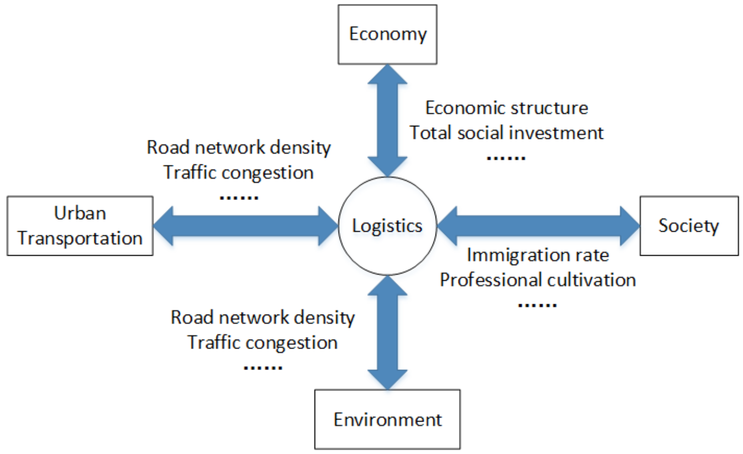


Figure 9 The relationship between urban logistics and other factors

3.3.1 Economic environment factor

Logistics and the economic environment are inseparable. The logistics industry is the carrier of physical capital flow. The significance of logistics is to realize the space-time benefits of materials through the reasonable docking of various nodes of logistics, so as to promote the development of local regional economy(Shihua, M., 2005). When the economy is well developed, it will release huge logistics demand and promote the better development of the logistics industry (Qianqian, L.,& Maochun, W., 2018). In addition, as a typical promoting industry, the logistics industry is of great significance for improving economic operation costs, transforming economic growth mode, and optimizing industrial structure. Therefore, it is also called the "accelerator" of economic development. The development practice of many countries and regions proves that the logistics industry has made great contributions in the process of economic development(Kunping, Z., 2007).

3.3.2 Social environment factor

The social environmental factors mainly include **labor supply** (i.e. logistics practitioners) and **urban employment**. Logistics practitioners refer to those who engage in logistics activities directly or indirectly. At present, China's logistics industry is in the stage of developing and upgrading. From base-level operators to top-level managers, the shortage of professional logistics talents is expanding. To improve the supply ability of urban logistics, on the one hand, **logistics talents are required to improve their ability and quality** to meet the needs of society and industry; on the other hand, the government and industry should also **pay attention to perfecting the personnel training system and cherishing the talent resources**.

3.3.3 Traffic environment factor

Road transportation is the most important method for urban logistics transportation, including the transportation of goods on urban highways and the distribution of goods in the city. Due to freight vehicles large weight, slow speed and inconvenient turning, freight vehicles often decrease the average speed of highways, causing traffic congestion and putting greater pressure on urban traffic. Reasonable transportation facilities planning and sufficient traffic road network density can provide material security for a smooth implementation of logistics. Therefore, transportation development should meet logistics needs. The government can allocate the proportion of road infrastructure investment and regulate the progress of road construction, to meet the traffic demand of passenger and freight, while avoiding waste of resources caused by excessive investment.

3.3.4 Ecological environment factor

From the outside, the uneconomical nature of logistics is mainly reflected in the side effects of the urban environment. The increase in the goods flow inevitably increases the use of freight vehicles, while the exhaust pollution from vehicles is the main source of urban air pollution. Vehicle exhaust pollution includes global gases (such as carbon dioxide) and local gases (such as carbon monoxide, nitrogen oxides, solid particulate matter, photochemical smog, hydrocarbons, sulfur dioxide, lead compounds, etc.). The pollution level of the urban environment will affect the urban population and economic development, which indirectly inhibits the development of logistics.

3.4 The Role of Public Policy

Urban logistics concerns the **development and stability** of a city. National and reginal government agencies can maintain an orderly and sustainable development of urban logistics through a series of public policies. Public policy should reflect the interests of the majority of society. It should be designed and implemented for the **optimal goal of the whole society**. Logistics public policy includes publicly released laws, regulations, plans, guidance documents or measures. In China, the current logistics policy system mainly includes two types of policies, which are **legal policies** (Various laws and regulations related to logistics) and **administrative policies** (various opinions and notices about logistics). It can also be divided into two levels as **the national policies** and **the regional policies**. For the hinterland cities in the central and western China, which have weak logistics foundation, the construction of logistics industry foundation needs more support from public policy. In addition to the **formulation of the policy system**, the **specific implementation of the policy** is also directly related to the effect of the policy. During policy implementation, feedback channels should be set up to support subsequent policy adjustments, forming a virtuous cycle.

3.5 Evaluation standard

Public interest is the value orientation and logical starting point of public policy. To evaluate whether the public policy leads to the **optimization of the public interest**, it is necessary to consider whether it can promote progress in multiple fields such as economic development, corporate profitability and urban competitiveness.

3.4.1 Meet the demand of economic development

The logistics demand for economic development refers to the space, time, and cost requirement about distribution raw materials, finished products, semi-finished products, commodities, waste materials and waste materials in the production, circulation and consumption sectors, in a certain period, which relates to variant aspects such as transportation, inventory, packaging, handling, distribution processing, and related information needs (Chunrong, Y., 2008). Meeting the logistics needs arising from economic development is the basic responsibility of the logistics industry, depending on the quantity and quality of logistics system services. When logistics meets the needs of economic development, it can promote further fine division of labor among various industries in the city, which is the basic guarantee for urban economic development.

3.4.2 Meet the demand of logistics corporate profitability

At present, China's total logistics costs are high (up to 12.1 trillion yuan in 2017), but logistics service companies have less surplus, and a large number of logistics enterprises are unable to make ends meet, making it difficult to maintain normal operations. In order to ensure the stable development of the logistics system, the growth of service supply subjects in the logistics system cannot be ignored. Therefore, ensuring the reasonable profit of the logistics industry is also an evaluation index of the development level of the logistics system.

3.4.3 Meet the demand of urban competitiveness

For urban logistics, not only the development of the logistics industry itself, but also the competitiveness and attractiveness of the city should be pay attention to. The development of logistics inevitably affects the urban environment, employment and urban transportation. Therefore, in addition to the improvement of logistics supply capacity, the reduction of environmental pollution, the increase of employment, the improvement of urban traffic congestion, which are all good for the competitiveness of cities, are also the evaluation indexes of the logistics system.

3.5 Chapter summary

In order to better study the urban logistics development strategy, the internal structure mechanism and open framework of urban logistics are first investigated in this chapter, including material basic elements, participating subject elements, and environmental elements. Considering the close interaction between logistics and economic, social, transportation and other environmental factors, this chapter is not limited to logistics itself, but fully considers the interaction between logistics and other factors. At the end of this chapter, from the perspective of comprehensive urban development, the evaluation indexes of urban logistics are analyzed, which are economic development, enterprise profitability, and city competition.

The research in this chapter provides a theoretical basis for the investigation of Chongqing in Chapter 4 and the establishment of the SD model in Chapter 5.

4. Current Situation and Challenge of Chongqing Logistics

Through the discussion of the overall system structure and evaluation standard of urban logistics in last chapter, it can be seen that although there is widely used skeleton structure of urban logistics in various cities, practical planning of different cities should be improved based on their own case study. It is necessary to enhance the maneuverability, adaptability and flexibility of urban logistics planning through example tests. The discussion in this chapter is mainly based on the case of Chongqing city logistics planning. As a typical urban logistics planning case, the overall planning of Chongqing logistics has positive and desirable aspects, but also has aspects that need to be further explored and deeply analyzed. The current situation and challenges of Chongqing logistics will be summarized in this chapter.

4.1 Material elements

Chongqing is a major industrial town in southwest China, one of the old industrial bases in the country. It has a large number of external transportation needs for automobiles, motorcycles, chemicals, machinery, steel, building materials and other products. The national "Belt and Road" strategy in 2013 has deeply affected the logistics industry structure of Chongqing and also presented new challenges to the Chongqing logistics system. As a municipality directly under the central government in the western inland region, Chongqing economic development has achieved remarkable results. However, due to the inherent disadvantages of geographical location in the past, Chongqing's previous foreign trade approach was mainly to transport goods to Shanghai and other regions through the Yangtze River Golden Waterway, or to Guangdong by road or railway, and then complete the foreign trade by Shanghai or Guangdong. In recent years, Chongqing 13th Five-Year Plan has vigorously developed logistics infrastructure, and the development of logistics system has entered a new era.

4.1.1 Location and geographical features

Chongqing is the only large city in the western region with five modes of transportation including railway, highway, waterway, aviation and pipeline. It has great potential for logistics development and has huge logistics demand. It plays an important role in the development of the western region and the strategy of the rise of the central region. (Yi, C.,&Hui, L.,&Tao, S., 2018).

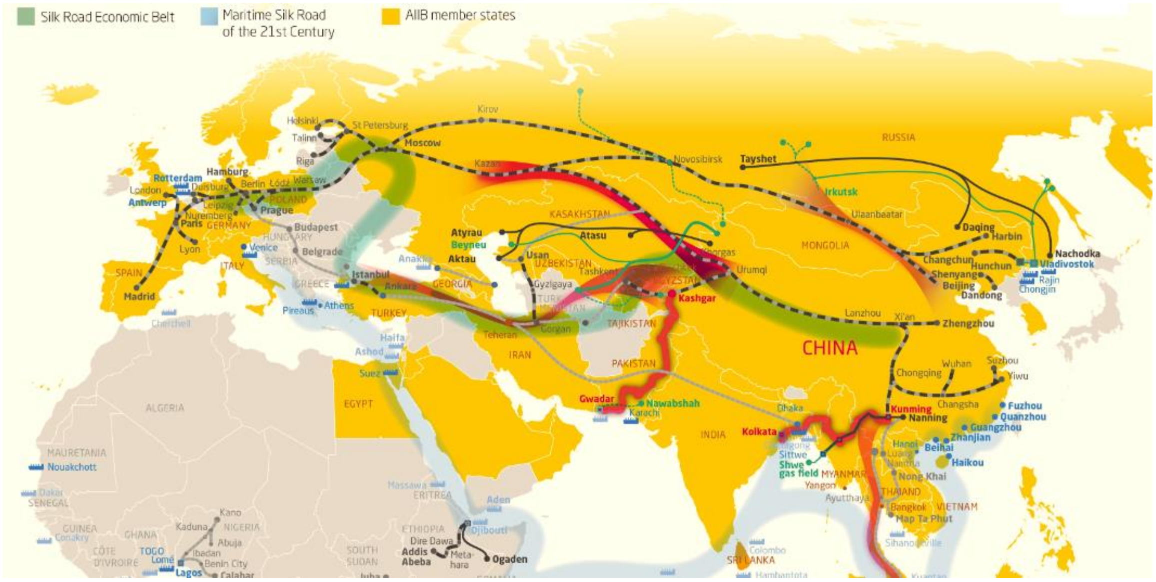


Figure 10 The Belt and Road infrastructure projects

Source: MERICS research

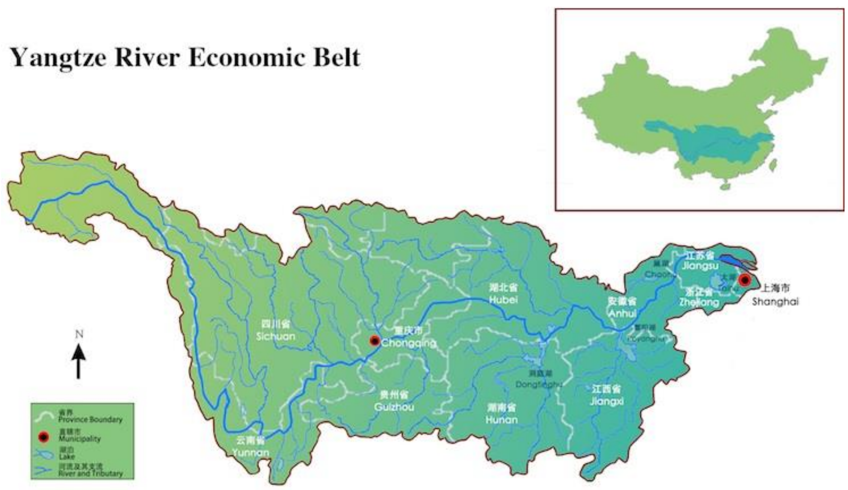


Figure 11 Map of Yangtze River Economic Belt

Looking over the two figures shown above, it can be seen that Chongqing is located on Y-shaped node of "Belt and Road" and the Yangtze River Economic Belt. It has the unique geographical advantages, connecting the East and the West, while linking the North and the South, which make it an important strategic fulcrum of the Silk Road Economic Belt, a central hub of the western Yangtze River Economic Belt, and a industrial hinterland of the Maritime Silk Road. (Mengqiu, L.,&Yu, C.,&Yulin, L., 2018).

Therefore, Chongqing logistics industry has been given important strategic significance. After continuous development in recent years, Chongqing has formed an efficient 3-D transportation network with many other large and medium-sized cities, and at the same time established an internal 3-D transportation network system according to its own development needs. The State Council of

China states that the Yangtze River Channel is China's most important east-west axis. Thus it is important to speed up the construction of the Yangtze River Golden Waterway integrated transportation system, including the Yangtze River shipping center and the regional airport hub in Chongqing. Overall, Chongqing has natural and political advantages for its logistics development.

Correspondingly, Chongqing is located at the junction of the Yangtze River and the Jialing River, blocked by Zhongliang Mountain and Zhenwu Mountain in the east-west direction. Due to the influence of the topography, the main urban land is scattered, forming a 9-part area that is divided and interconnected. Complex terrain has brought great resistance to the development of Chongqing transportation capacity.

Figure 12 Topography in the main urban area of Chongqing

4.1.2 Scale and layout of logistics nodes

The logistics nodes discussed in this section include logistics parks, logistics centers, distribution centers, ports, freight stations, and air freight hubs. In order to avoid waste of resources caused by redundant construction of logistics facilities, the construction of logistics nodes (especially large-scale logistics parks and logistics centers) and logistics facilities in Chongqing have been mostly planned and macro-controlled by the government. In the “13th Five-Year Plan” of Chongqing, it is clear to enhance the coordination and linkage development capabilities of various logistics spaces. While building a national-level logistics park platform, the capacity of Wanzhou District, Fuling District, Jiangjin District, Changshou District, Yongchuan District, Hechuan District and other city-level logistics nodes will be enhanced, and other district-level logistics nodes function will be improved, to form a three-level logistics network system. The key logistics platform will be built as the support, the district-level logistics nodes as the links, and the urban/rural community commercial outlets as the end. The scale and layout characteristics of the logistics network system in Chongqing will be examined in detail in this section.

Three-level logistics node network in metropolitan Area

The plan and construction of Chongqing Logistics Park began in the early 21st century. In 2003, the “Chongqing Modern Logistics Industry Development Plan” was announced, from which logistics bases such as Cuntan Port and Tuanjie Village started to be planned and constructed, which ended a development history of scattered distribution and backward technology in the logistics industry, and began to plan and build modern logistics parks.

Currently in the latest plan, Chongqing Metropolitan Circle will build a “3+12+N” three-level logistics node network system. The first-level network relies on the national hub platform to deploy and construct three major hub-type logistics parks, namely Chongqing Western Modern Logistics Park, Chongqing Aviation Logistics Park, and Orchard Port Logistics Park, with the five functions including inland free trade procurement centers, supply chain financial centers, port industrial service center, logistics big data center, and logistics trade collaborative innovation center. The second-level network relies on 12 regional transportation hubs for area service, including Jiangjingehuang Logistics Park, Fuling Longtou Port Logistics Park, Wanzhou Xintian Port Logistics Park, Nanpeng Trade Logistics Base, East Railway Logistics Park, Baishiyi Shuangfu Agricultural Products Logistics Park, Hechuan Weituo Logistics Park, Changshou Chemical Logistics Park, Yongchuan Port Modern Logistics Park, Zhongxian Xinsheng Port Logistics Park, Qianjiang Zhengyang Modern Logistics Park, and Xiushan Modern Logistics Park. In the districts and counties of Chongqing metropolitan area, combined with the layout of the above-mentioned key logistics parks, relying on transportation infrastructure, population agglomeration areas and core industrial parks, a number of distribution-type logistics parks are planned and constructed, with urban and rural distribution functions, serving the production and life of the administrative region, forming the third level logistics network.

Main city logistics node network

The first level and part of the second level of the “3+12+N” three-level logistics node network system in the Chongqing metropolitan area are located in the main urban area of Chongqing. Huiming, Z. (2015) conducted a number of on-the-spot investigations on the logistics park in the main city of Chongqing, and interviewed the business personnel of the logistics park management departments. Through the collection of relevant data, it is believed that the development of the logistics park in Chongqing started late and is still in the stage of extensive expansion.

At present, there are 7 large-scale logistics bases in planning or under construction in the main urban area of Chongqing, including three bases and four port areas, as shown in Table 3, which constitutes the core skeleton of the logistics industry layout in the main urban area of Chongqing. Among them, only the construction of the Cuntan Bonded Port and the Airport Logistics Park is completed, and others are still under construction. At present, the development of logistics parks in Chongqing is focused on expansion and construction, and the stationed enterprises are mainly traditional logistics and warehousing enterprises, lack of large-scale comprehensive logistics enterprises or third-party logistics enterprises at home and abroad. There is still a large gap with modern logistics parks for certain functions.

Table 3 Logistics Parks in Chongqing's Main City (Huiming, Z., Pengcheng,W., & Jicai, D., 2015)

Park Name	Location	Plan Area	State	Total Investment	Annual Throughput
Western Logistics Park	Xiyong Group in Shapingba	33 km^2	Phase II completed	111.7 billion yuan	2m TEU
Cuntan Port	Cuntan Street in Jiangbei	2.43 km^2	Total completed	5 billion yuan	2m TEU

Banan Highway Logistics Base	Nan Peng Town in Banan	7 km^2	Under early phase construction	10 billion yuan	100m tons
GLP Jiangbei Airport Base	Lianglu streets in Yubei	5.94 km^2	Total completed	43.8 million dollar	500k tons
Orchard port	Yuzui Town in Jiangbei	12.86 km^2	Phase III completed	10.5 billion yuan	30m tons
GLP Eastern Port	Guangyang Town in Nan'an	15 km^2	Phase II under construct	/	1300k TEU
Huanglian Port	Xi Peng Town in Jiulongpo	1 km^2	Phase I restart	1 billion yuan	3000k tons

Data sourse: Chongqing Three Bases and Four Ports Logistics Planning

As shown in Table 3, it can be analyzed that the spatial layout of the logistics park in the main urban area of Chongqing presents two major characteristics (Huiming, Z., Pengcheng,W., & Jicai, D., 2015).

The first feature is that the main urban logistics park layout outer ring of the city. As shown in Figure 13, except for the Cuntan Bonded Port Area which is located near the inner ring of the city, the other six logistics parks are located near the Second Ring Road and the outer ring of Chongqing.

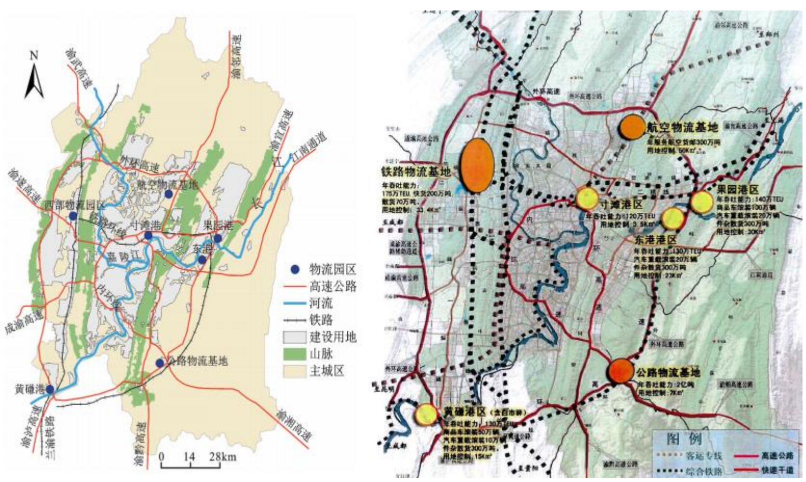


Figure 13 Spatial layout of the seven major logistics parks in the main city of Chongqing

There are two reasons for this spatial layout feature: the first is the role of economic and market factors. As a mountainous city, Chongqing has a limited core area and a high construction density with high land price. The land used for the logistics park is with the features of low building volume ratio and large floor space, and low land prices are expected. Due to the high cost of land use and traffic congestion, the logistics enterprises originally located in the central area have to move out. The second reason is the government planning and regulation. The government has consciously planned the industrial land and logistics supporting land to be used outside the city to guide the industrial and logistics enterprises to migrate outward.

The second feature is that, the location of logistics nodes are close to important transportation facilities. Chongqing logistics parks are all close to airport, docks, railways, highways or urban traffic arteries. Most logistics parks choose to be close to a variety of transportation facilities to form a water-land-air multimodal transportation. For instance, regarding to Cuntan Port and Orchard Port, there are important river ports of the golden waterway in the Yangtze River, as well as the railway freight stations directly to Europe, and highways directly to Chongqing Jiangbei Airport and all parts of the country. The coordinate of water, railway, bus and air transportation is seamless.

4.1.3 Logistics cargo transportation capacity

International and domestic trade channels

Under the guidance of the "Belt and Road" strategy, Chongqing has realized the layout of four major international logistics channels, which are Chongqing-Xinjiang-Europe, ASEAN Highway, Chongqing-Guangxi-Singapore, Jianghai Grand Corridor. The Chongqing-Xinjiang-Europe railway combined transport logistics channel realizes the north and west extension of Chongqing, traversing the Eurasian continent and connecting Duisburg in Germany. The ASEAN international highway corridor forms a point-to-point connection between Chongqing and ASEAN countries. The Chongqing-Guangxi-Singapore has realized the southward extension of Chongqing, runs through the Indochina Peninsula, connects Singapore, and connects Southeast Asia and European countries via Singapore, forming a closed loop of Chongqing's international trade and logistics channel to the European market. The Jianghai Grand Corridor guarantees the water transportation connection between Chongqing and the American countries or Japan&South Korea.

By 2020, Chongqing's expressway network has completed the network layout of "Three rings, ten rays and three links" on the basis of the original "Two rings eight rays". The new expressway network covers all 40 districts and countries of the city, and realizes the connection of all important highway, waterway, railway and aviation hubs. The density of expressways in Chongqing reaches 44 kilometers per 100 square kilometers.

There are four main ways of transporting goods: railway, highway, waterway and aviation transportation. In recent years, waterway and rail transport have been widely used in bulk shipping and international container transport because of their large-scale transportation capacity and relatively low freight rates. Air transport is suitable for the transportation of high-value goods or emergency supplies due to its fast but high freight rate. Because of its fast and safe characteristics, road transport is widely used for the transportation of goods in and around the city.

Table 4 shows the composition of Chongqing freight traffic and freight turnover in 2016. Compared with all kinds of transportation business, road transportation accounts for 82.89% of the total freight volume, with an absolute position in Chongqing logistics transportation. Waterway transportation accounts for 14.74% of the total freight volume, while railway and civil aviation transport accounts for a small proportion. From the perspective of cargo turnover, waterway and highway accounted for 94.83%, while railway and civil aviation accounted for the same proportion. We believes that the construction of the Chongqing Expressway Network and the Three Gorges Project is the main reason for the growth of Chongqing highway and waterway logistics transportation. The unique advantages of the Yangtze River Golden Waterway in Chongqing have been brought into play, and there is still much room for improvement in railway logistics.

Table 4 Composition of Logistics Freight Volume and Freight Turnover in Chongqing (2016)

Delivery method	Freight Volume		Freight Turnover	
	Absolute Value/10 thousand tons	Proportion/%	Absolute Value/100 million tons km	Proportion/%
Railway	1789	1.66	151.23	5.1
Roadway	89389	82.89	935.45	31.55
Waterway	16649	15.44	1876.1	63.28
Aviation	13	0.01	1.99	0.07
Sum	107840	100	2964.77	100

Railway transportation infrastructure

By the end of 2015, Chongqing railway operation mileage reached 1,929 kilometers, while the road network density reached 234 km/10,000 square kilometers, covering 27 districts and counties, opened up the Chongqing large, east, north and other major foreign channels, resulting a gradually open of high-speed railway. The newly-opened New European international freight trains for railway freight transport and the Five-Set freight trains from Chongqing to Guangzhou and Shenzhen have been normalized. Chongqing New European Express has become the main channel for China-EU trade on land freight.

There are still some problems in the Chongqing Railway. First, the standard of the external railway channel is low, and there is insufficient direct contact with the surrounding provincial capital cities. Second, the railway network layout is not perfect. Third, the layout of the hub is unreasonable. Fourth, the level of railway freight services is low. In 2015, rail freight volume only accounted for 1.68% of the total annual freight volume, which is lower than the national average of 9%. Figure 14 shows the volume of Chongqing railway freight traffic in the past five years.

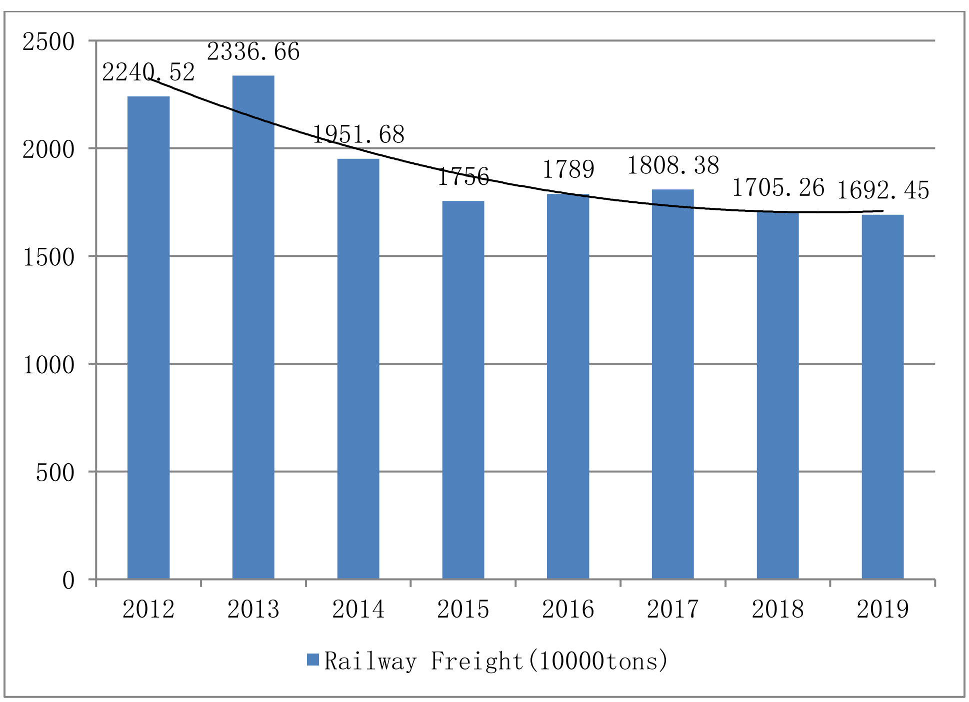


Figure 14 Changes in freight volume of Chongqing railway transportation in the past eight years

Road transportation infrastructure

Due to the long-term tension of Chongqing railway capacity, a large number of freight demand flows to road transport. At present, Chongqing has built a Two-ring and Eight-shot expressway centered on the main city. In 2015, the city total expressway mileage reached 2,525 kilometers. It is planned that, by 2020 the layout of Three Rings, Ten Shots and Triple Lines will be completed, with a total investment of RMB 199 billion and a 3,600 km expressway (Dong, B., 2011). In recent years, Chongqing road freight volume has maintained more than 80% of the total transportation volume. Figure 15 shows the traffic volume of Chongqing's roads in the past five years.

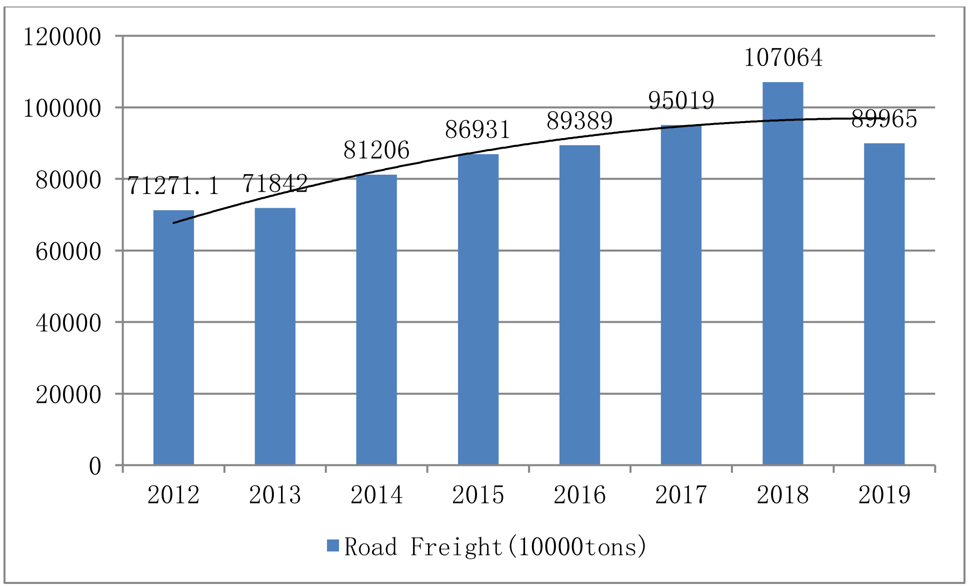


Figure 15 Changes in freight volume of Chongqing road transportation in the past eight years

Waterway freight infrastructure

Chongqing is the only transportation hub in the west with three transportation modes of water, land and air. The proportion of water transportation is second only to road freight, accounting for nearly 15%, and is currently establishing a “1 + 3 + 9” port group. It is expected that, by 2020 the cargo throughput will reach 220 million tons. Figure 13 shows the trend of Chongqing waterway freight volume change in the past five years.

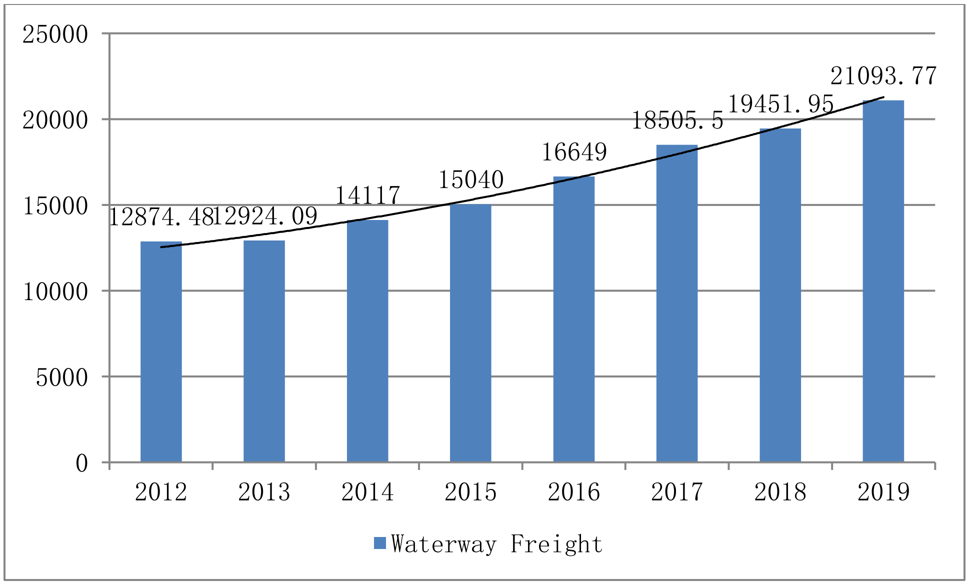


Figure 16 Changes in freight volume of Chongqing waterway transportation in the past five years

Air freight infrastructure

The development of e-commerce has brought huge growth space to the aviation and express delivery industry in Chongqing. In 2016, the cargo throughput of Chongqing Airport reached 360,000 tons, a year-on-year increase of 12%. The international cargo and mail throughput were 99,000 tons, a year-on-year increase of 12%, accounting for about one-third of the total aviation logistics. The development goal is to reach 1.1 million tons of cargo and mail capacity by 2020. Figure 17 shows the trend of air cargo transportation volume in the past five years.

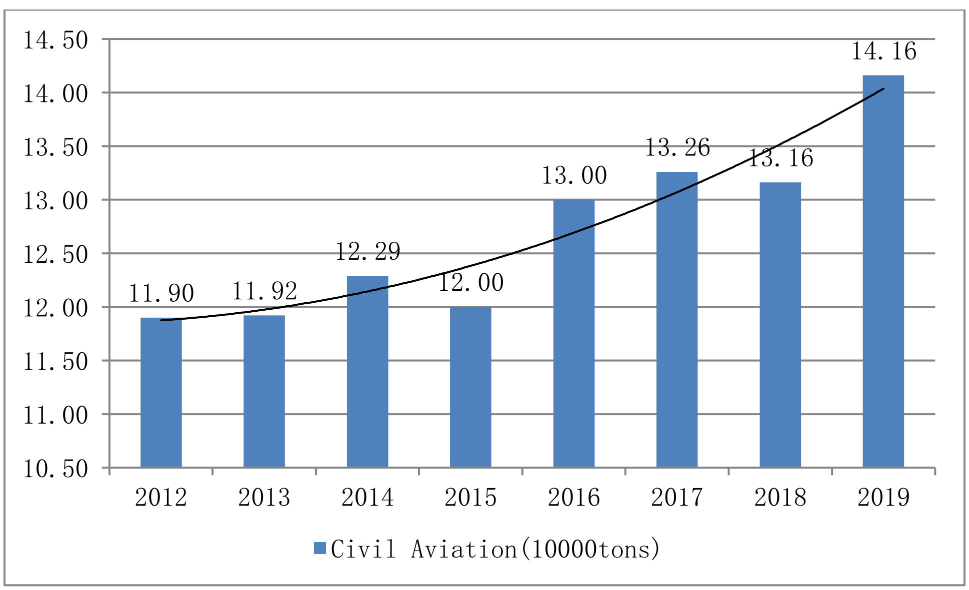


Figure 17 Changes in cargo volume in Chongqing air transportation in the past five years

4.1.4 Information platform and new technology

Logistics information platform and new technology equipment are important targets for realizing the supply side reform of the logistics industry. They are an important carrier for reducing costs and increasing efficiency, aiming at solving the conflicts of long logistics value chain, standardization and personalized logistics services. At present, China's more widely used logistics information platform mainly focuses on the logistics market segment. For example, “Full Truck Alliance” focuses on the matching of goods in the road transportation field, and “Lalamove” focus on urban logistics and distribution.

Chongqing has made new attempts in the logistics information platform in recent years. In 2018, led by the Chongqing Municipal Development and Reform Commission, Chongqing Jiaoyun Group, as an investment entity, built a public information platform for the logistics industry, Chongqing Smart Logistics Public Information Platform, which was selected by the National Development and Reform Commission, the Ministry of Transport, and the Central Network Office. The first batch of 28 backbone logistics information platform pilots have created a logistics industry-wide industrial chain platform, built a shared logistics ecosystem, promoted the development of multimodal transport, realized the interconnection of various modes of transportation of iron and water, and then relied on multimodal transport. The big data of trunk transportation and the development of urban logistics joint distribution.

The platform will also open up all the logistics links of production, transportation and distribution of various logistics parks to support the development of supply chain integrated logistics operations. At present, Chongqing's smart logistics public information platform has more than 300 logistics companies registered to carry out business, has been on the line for the online and offline freight market combined freight information transaction subsystem - bee wisdom, will soon be online multimodal, Logistics park cloud, urban logistics and other subsystems.

Although Chongqing has made some new attempts and efforts, in general, most local logistics companies in Chongqing still have large gaps with the developed countries in the application of new technologies and information platforms, such as automated warehousing and automatic extraction. Systems, wireless scanning equipment, and logistics management information systems have generally mature applications in developed countries, greatly improving the efficiency of logistics management operations. The application rate of local logistics enterprises to new technologies and new achievements is not high, and the development of network technology behind. The construction of the public information platform for logistics information has only preliminary results and needs to be strengthened. Enterprises, enterprises and government units cannot carry out timely information exchange and sharing. The information island phenomenon is still widespread, and the logistics operation efficiency is low.

4.2 Stakeholders

4.2.1 Demand subject

The demand for urban cargo transportation mainly includes the distribution of living materials for urban residents and the transportation between the main sources of goods and demand points. The main goods demands subjects include: large industrial parks, large wholesale markets, commercial enterprises, and urban residents.

Large industrial parks: The industrial parks in the main urban area mainly include Tongxing, Jingkou, Xiyong, Jiulong, Jianqiao, Xipeng, Konggang, Lianglu, Yuzui, Gangcheng, Changjiang, Chayuan, Lujiao, Moju, Huaxi and others. Basically, the industry parks mainly composed of automobiles and motorcycles, equipment manufacturing, high-tech, and mordern service industries, which are mainly distributed **between the inner and the outer ring expressway**.

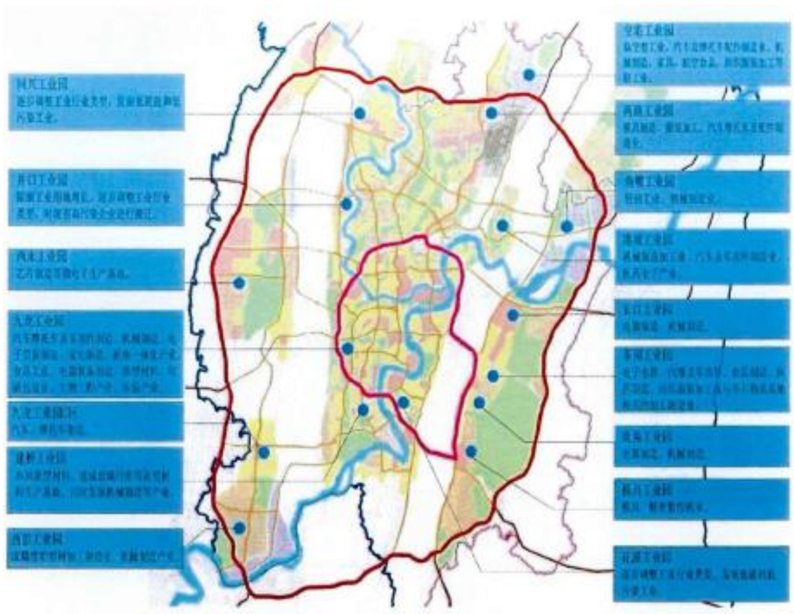


Figure 18 The industrial park map in main urban area

Large wholesale market: The main city professional wholesale market has a complete range, mainly including steel, building materials, wood, small commodities, auto and motorcycle accessories, hardware and machinery, farm products, medicine, etc. As the main city serves as the transportation hub of the Yangtze River Economic Belt, most markets not only **serve the local area**, but also **radiate to the surrounding areas**, basically **gathering in the city center area within the inner ring**. After years of cultivation, the markets are extremely dynamic, but due to the age, many market forms can **no longer meet the needs of modern urban development**. They have various degrees of problems such as unreasonable layout, traffic jams, insufficient storage facilities, primitive information processing methods, and backward transaction modes.

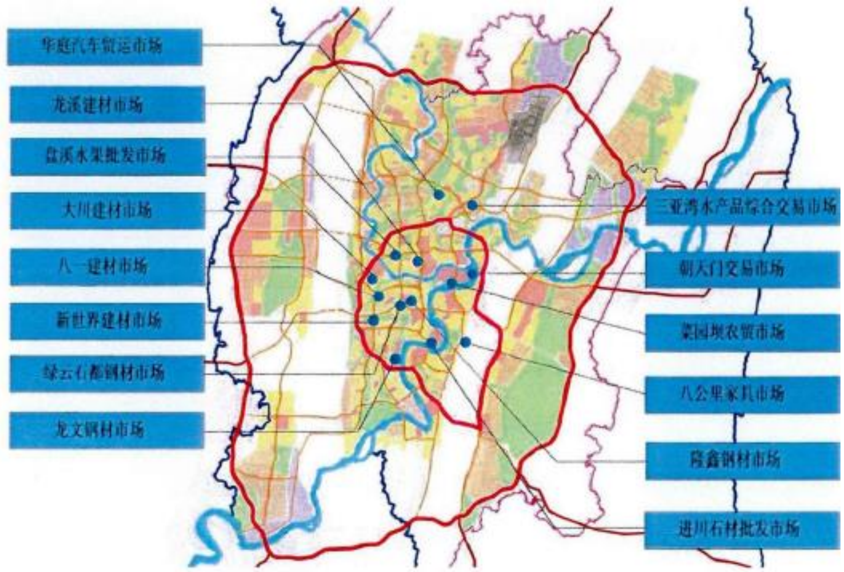


Figure 19 The location of major wholesale markets in main urban area

Commercial enterprises: The layout of commercial enterprises is **relatively scattered**, directly serving consumers, including department stores, supermarkets, and building materials stores. Till 2017, there are 82 shopping malls in Chongqing, with a total stock of 8.49 million square meters, surpassing Guangzhou and Shenzhen, and rank the fourth in the country, achieving full coverage of counties, and increased to 133 by the end of 2019.

Consumer Residents: Chongqing total retail sales of consumer goods in 2017 was 806.8 billion yuan, a year-on-year increase of 11% of which online retail sales were 24.37 billion yuan, a year-on-year increase of 27.4%. It is worth mentioning that the per capita consumption of e-commerce consumption in Chongqing has grown rapidly. There were over 300 residents spending over a million yuan on online shopping last year. **The rapid growth of e-commerce consumption has brought a large amount of logistics demand**. In 2018, it has squeezed into the top ten provinces and cities in the country, ranking seventh, and the number of residential parcels in Chengnan Homeland and Kangju Xicheng ranked the top ten in China.

4.2.2 Supply subject

According to data from Heqin Consultants in 2019, there are too many enterprises in the logistics market in Chongqing, while the industry concentration is low. The proportion of operating income of major enterprises is 12%, and the competitiveness and scale of enterprises are not high enough. The product does not have differentiation, and the homogeneity competition is fierce. Competitors mainly use specialization, scale and price as the means of competition.

The overall supply market of the logistics industry presents a pyramid-shaped three-tier distribution. According to the difference of service objects and characteristics of logistics supply, it can be subdivided into three levels: high-end, mid-end and low-end. The lowest level, which is the less-than-one carload company, has the largest number. The middle level is a relatively large number of medium-sized express and logistics companies, while the top-level large-scale express and integrated logistics companies have a small number. As a whole, it presents the characteristics of small enterprise scale, low bidding ability, low industrial competition, and low industry barriers.

At present, the logistics industry in Chongqing can be divided into four strategic groups. The first group comprises strong local logistics companies in Chonqing represented by Chongqing Port and Changan Minsheng. As a leading group, it has a solid foundation, rich resources, large market share, and a stable customer base. The second group is the well-known foreign company and domestic magnates represented by UPS, CNPC, and COSCO. It belongs to the high-end group and basically controls the high-end market in Chongqing. It has built professional services and a leading market position. The third group is some local companies in Chongqing, which is a follower. It has a certain reputation and relatively strong strength and mainly engaged in professional logistics services. The fourth group is a group of small companies, which is struggling group. They are small in scale and would be easily merged and integrated in market competition.

4.2.3 Supervision Subject

Logistics management agency

In order to solve the segmentation problem of the current urban logistics management system, the Chongqing government has set up a logistics department, namely the Logistics Coordination Office of Chongqing Municipal Government, which is mainly responsible for formulating the city logistics industry development planning, supporting policies and logistics standards. It also aims at meeting the logistics needs of import and export, opening up logistics channels such as railways, aviation, highways and waterways, ensuring the normal operation of international channels such as “Chongqing-XinJiang-Europe” and “Jianghai Grand corridor”, opening cargo routes for Europe, America, Asia Pacific and other regions.

Logistics industry association

Chongqing has established more than ten industry associations related to logistics, including Chongqing Port Association, Chongqing Logistics and Supply Chain Association, Chongqing Logistics and Storage Association. Among them, the Logistics Association has the strongest representative, with more than 254 member units, 45 vice presidents and above member units. Its main business scope includes: accepting research commissioned by governments at all levels to carry out logistics industry support policies, planning layout, related topics, etc.; holding Chongqing logistics industry and manufacturing linkage development, Chongqing logistics investment, logistics resources and logistics equipment, providing logistics solutions, logistics efficiency assessment, logistics management and project consulting and planning services for industrial and commercial enterprises, carrying out logistics industry training and academic exchanges, cooperating with relevant departments to formulate logistics industry standards, quality standards, standardize service prices, strengthen industry self-discipline, and protect equal competition.

4.3 Environmental elements

4.3.1 Economic environment

Industrial structure and GDP

The scale of the logistics industry generally refers to the sum of output value created by the logistics industry, the employment of the logistics industry, the total value of the logistics enterprise, the number of logistics enterprises, and the total volume of logistics transportation completed, in a certain country or region within a certain period of time. Due to the different scope of China's industrial classification and economic statistics, the output value of logistics is usually examined by the output value of transportation and warehousing postal industry.

Table 5 shows Chongqing's total GDP of the logistics industry, GDP of the tertiary industry, GDP of the city, with the proportion of the logistics industry in the tertiary industry and in the city GDP, from 2006 to 2016. It can be seen that Chongqing is **realizing the adjustment of industrial structure**, and the proportion of the tertiary industry has increased year by year, reaching 48.41% in 2016. However, the **proportion of logistics-related transportation, warehousing and postal industry output value has been declining** year by year. From 2006, logistics accounted for 15.74% of the tertiary industry and only 9.98% in 2016. With the analysis about China logistics industry, the decline in the proportion may be due to the following reasons. First goes the logistics costs decline, while the decline is limited. Second, the modern manufacturing and service industries in Chongqing remain relatively rapid growth, in comparison, the growth rate of transportation and warehousing postal industry is relatively slow. Third, in recent years, Chongqing has invested heavily in transportation infrastructure, the logistics capacity has improved rapidly, resulting an intermittent excess of transportation capacity which has led to increased market competition and slowed down the development of the entire industry. Fourth, due to the ambiguity of statistical caliber and industrial classification, some logistics activities belonging to the modern logistics industry are not included in the statistical scope. From Figure 20, the year-on-year trend of Chongqing logistics industry gross production value and Chongqing tertiary industry GDP, it is obvious that the development rate of Chongqing logistics industry output value is far behind the overall development rate of the tertiary industry.

Table 5 Comparison of Chongqing GDP, tertiary industry output value, and logistics industry output value (2006-2016)

Year	GDP/100 million	Tertiary Industry Output Value		logistics industry output value			
		Absolute Value / 100 million	Proportion in GDP / %	Absolute Value / 100 million	Proportion in Tertiary Industry / %	Proportion in GDP / %	growth rate
2006	3907.23	1649.2	42.21	259.59	15.74	6.64	18.55
2007	4676.13	2011.92	43.03	293.63	14.59	6.28	13.11
2008	5793.66	2631.68	45.42	377.32	14.34	6.51	28.50
2009	6530.01	2984.54	45.70	427.88	14.34	6.55	13.40
2010	7925.58	3709.1	46.80	501.47	13.52	6.33	17.20
2011	10011.37	4704.04	46.99	592.24	12.59	5.92	18.10
2012	11409.6	5294.78	46.41	604.08	11.41	5.29	1.99
2013	12783.26	5968.29	46.69	659.65	11.05	5.16	9.2
2014	14262.6	6672.51	46.78	705.83	10.58	4.95	7
2015	15717.27	7497.75	47.70	761.31	10.15	4.84	7.86
2016	17559.25	8500.36	48.41	848.22	9.98	4.83	11.42

Data source: 2006-2017 Chongqing Statistical Yearbook

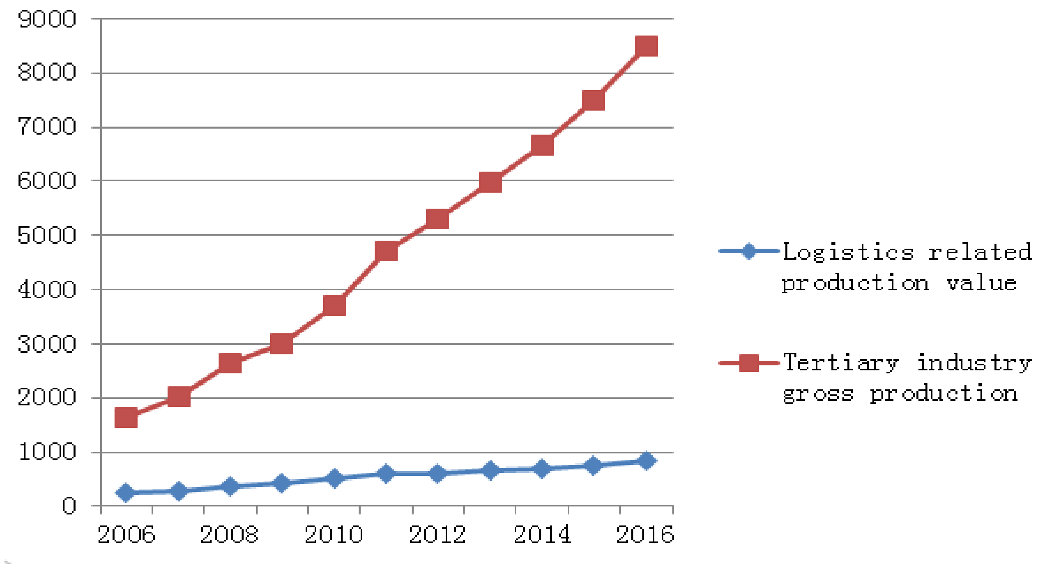


Figure 20 Comparison of Chongqing Logistics GDP and the Tertiary Industry GDP

Fixed assets investment

Table 6 shows the fixed assets investment in Chongqing logistics industry in recent years. It can be seen that Chongqing fixed assets investment in the tertiary industry accounts for 64% of the total fixed asset investment in the whole society, and the proportion of fixed assets investment in the logistics industry accounts for 11% of the total fixed asset investment in the whole society. The investment amount is increasing year by year. The proportion of fixed assets investment in the whole society is basically stable at around 11%, with fluctuations in different years.

Table 6 Fixed Assets Investment in Chongqing Logistics Industry (2010-2016)(100 million yuan)

Year	whole society fixed assets investment/100 million	Tertiary industry investment / 100 million	Proportion in whole society fixed assets investment /%	Logistics investment/100 million	Proportion in Tertiary Industry /%	Proportion in whole society fixed assets investment /%
2010	6934.797	4246.899	61.24	791.128	18.63	11.41
2011	7685.87	4622.349	60.14	833.506	18.03	10.84
2012	9380.001	5941.025	63.34	1054.607	17.75	11.24
2013	11205.029	7229.281	64.52	1350.372	18.68	12.05
2014	13223.746	8568.967	64.80	1436.214	16.76	10.86
2015	15480.325	9949.124	64.27	1739.046	17.48	11.23
2016	17361.121	11136.67	64.15	2003.39	17.99	11.54

Data source: 2006-2017 Chongqing Statistical Yearbook

Import & Export trade development

After Chongqing became a municipality directly under the Central Government, the total trade volume has continued to increase. Until 2014, Chongqing's import and export trade volume has maintained an upward trend. In 2015, due to the impact of the international economic situation, the import and export trade dropped significantly, and it rebounded from 2016 to 2019, as shown in Table 7.

Table 7 Main import and export trade data of Chongqing (2010-2019) (USD 10000)

Year	Total Value	ASEAN	European Union	American
2010	1242634	-	-	171868
2011	2921786	-	-	405594
2012	5320358	981901	1204308	931193
2013	6870410	1218005	1407667	1064565
2014	9545024	1895460	1520616	1367602
2015	7447656	1341927	1229203	1392165
2016	6277125	1104766	1076637	1101196
2017	6660391	1173710	1246659	1275173
2018	7904012	1148934	1485422	1610272
2019	8396406	1576273	1544705	1412224

Data source: 2011-2020 Chongqing Statistical Yearbook

4.3.2 Social employment and talent supply

As can be seen from Table 8, in 2016, the proportion of employment in the transportation and warehousing industry in Chongqing accounted for 4.04% of the total number of employed people in the region. In combination with Table 5, the output value created is about 4.83% of the city's GDP, and thus the prospects for the development of the logistics industry are still broad. At the same time, as shown in Table 8, since 2010, the number of employed people in the logistics industry has increased year by year. After reaching the highest growth rate in 2013, the growth rate of logistics employment in the past three years has been somewhat ups and downs. Combined with Table 5, after the growth rate of logistics output value suddenly dropped to the lowest in 2012, the output value of logistics has rebounded sharply in the past three years. It can be argued that, the rapid development of urban economy and the rise of modern e-commerce in recent years have prompted the rapid development of the logistics industry, and created more job requirements. In this process, the growth rate of logistics practitioners lags far behind that of logistics industry.

Table 8 Employment and Growth Rate of Logistics Industry in Chongqing (2010-2019)

Year	Total employment/10 thousands	Logistics employment		
		Absolute Number/10 thousands	Proportion in total employment/%	Growth Rate/%

2010	1539.95	50.12	3.25	3.51
2011	1585.16	53.49	3.37	6.72
2012	1633.14	56.88	3.48	6.34
2013	1683.51	61.27	3.63	7.72
2014	1696.94	64.93	3.82	5.97
2015	1707.37	67.03	3.92	3.23
2016	1717.52	69.45	4.04	3.61
2017	1715	73.13	4.26	5.29
2018	1710	72.10	4.21	-1.40
2019	1704.54	72.38	4.24	0.38

Data source: Chongqing Statistical Yearbook (2020)

According to the Blue Book of China Logistics Talents Professional Ability Construction (2016), the demand gap of China high-quality skilled logistics talents is huge, not only the total supply is insufficient, but also the personnel structure is unreasonable, which seriously restricts the rapid development of modern logistics industry. The gap is reflected in the expansion of the industry demand and the logistics talents supply shortage. According to the Medium and Long-Term Plan for the Development of Logistics Industry (2014-2020), China logistics employees are growing at an average annual rate of 6.2%, adding 1.8 million new jobs each year. Although there are more than 2,000 logistics professional colleges and universities training about 150,000 logistics talents for the society every year, with third-party institutions training about 170,000 and public base training about 140,000 talents in addition, the number of logistics talents still cannot meet the social demand for logistics talent.

In the past two years, there has been an unprecedented phenomenon of talents recruitment in China, and Chongqing has also introduced a number of talent attraction policies, such as the policy of setting residency with parents with spouses without a threshold, cash incentive policy for high-level talents, named Hongyan Plan, and the establishment of a number of special funds to attract domestic and foreign talents to innovate or start a business. Chongqing has just been rated as a new first-tier city in 2017. Together with Chengdu, Chongqing has built an important economic driving force in southwestern China. With plenty of employment opportunities in the mature twin cities together with the quality of life, Chongqing's ability to attract talents is rapidly increasing. According to the 2017 Graduate Recruitment Report, Chongqing ranks fourth among the top ten cities in terms of resumes for 2017 graduates, just behind Guangzhou, Chengdu and Beijing.

4.3.3 Transportation

Chongqing consists of 26 districts, 8 counties and 4 autonomous counties, of which the main urban area contains 9 districts. According to the 2017 statistics, the proportion of the main urban area is only 6.6% of the whole city area, while the GDP of the main city accounts for 43% of the whole city. It can be seen that the main urban area has concentrated most of Chongqing transportation facilities, logistics needs and economic activities, while there are also serious traffic congestion problems. Therefore, the traffic conditions in the main urban area have a greater impact on the urban distribution capacity. This paper mainly analyzes the traffic situation in the main urban area of Chongqing (Data source: Annual report on traffic development in the main city of Chongqing, 2017).

Road traffic facilities

There are 4,654 kilometers urban roads in the main urban area of Chongqing, including express roads, trunk roads, secondary trunk roads and branch roads. Table 9 summarizes the main urban roads in Chongqing, in which table the Road Network Density is derived as the factor of more than 2 million residents city from the Urban Road Planning Indicators. It can be seen from Table 8 that Chongqing main city road network density index can basically meet the national regulations, but due to the rapid expansion of urban population, the rapid increase in the number of motor vehicles, coupled with the unique mountainous terrain of Chongqing, various roads are commonly narrow and its traffic capacity is severely constrained. When trucks, especially large trucks, enter the main city, given to the current road conditions, Chongqing main urban area will bear more severe traffic pressure than other cities.

Table 9 Summary of Chongqing Main City Road

Type of road	Length		Density (km/km^2)	
	Absolute Length (km)	Proportion (%)	Actual value	Specified value
Express roads	408	8.77	0.69	0.4-0.5
Trunk roads	906	19.47	1.52	0.8-1.2
Secondary trunk roads	1080	23.21	1.82	1.2-1.4
Branch roads	2260	48.56	3.80	3.0-4.0
Sum	4654	100	-	-

Due to the unique location of Chongqing which crossing the two rivers and the two mountains, a large number of bridges and tunnels have been built in the city. Till 2017, Chongqing has a total of 27 municipal road bridges across the Yangtze River and Jialing River. The lack of transportation capacity caused by bridges and tunnels has become a bottleneck in the road network, resulting a relatively poor reliability. Once congestion occurs under the rapid increase of demand for motorized traffic, it will spread rapidly to the entire network. Cross-river bridges with daily traffic exceeding 150,000 Standard Car Units (PCU) frequently have serious traffic jams, such as Jialingjiang Bridge-Yiaoao Bridge, Egongyan Bridge, and Huanghuayuan Bridge, especially when they are the main channels connecting major business districts with a lot of trade. Adopting reasonable traffic management measures for trucks must not only ensure the normal operation of trucks, but also avoid greater congestion, which can promote the sustained and rapid growth of the local economy.

Main city traffic operation situations

The traffic operation index is used to further illustrate the traffic congestion in Chongqing. The traffic operation index is a conceptual index value that comprehensively reflects the smooth or congested road network, and is often used to qualitatively describe the traffic operation. The value range is 0-10, which is divided into six levels: smooth, basically smooth, slow, mildly congested, moderately congested, and severely congested. The higher the value, the more serious the traffic congestion. The specific congestion status and the index value are shown in Table 10.

Table 10 Traffic Operation Index Range Corresponding to Congestion Level

Congestion condition	Smooth	Basically smooth	Slow	Mildly congested	Moderately congested	Severely congested
Index	0-2	2-3.5	3.5-5	5-6.5	6.5-8	8-10

In addition, if it is necessary to quantitatively calculate the degree of traffic congestion, the Traffic Load Intensity is often used as an indicator. Traffic Load Intensity is the ratio of traffic intensity to road carrying capacity. The corresponding relationship between value range and congestion is shown in Table 11.

Table 11 Traffic congestion intensity assessment for traffic congestion (Zheng, H., 2014)

	Smooth	Mild congestion	congestion	Severe congestion
Traffic Load Intensity	≤ 1.8	1.8-2.3	2.3-3.2	≥ 3.2

According to the 2017 annual report on the traffic development of the Chongqing main city, the traffic conditions in the main urban area of Chongqing in 2016 and are shown in Table 12. In the morning and evening peak hour of the main city (the morning peak of workday is 7:30-9:30, the evening peak is 17:00-19:00), the traffic operation index reaches 4.2. The full-day peak hour traffic operation index is 4.9 (referring to the highest hour of traffic operation index in all time periods throughout the day), the road network operation has fully entered the slow-moving state. In the morning and evening peak hours, the proportion of congestion mileage is 6.7% (in the morning and evening peaks, the proportion of road network congestion per five minutes) increased by 2.1 percentage points year-on-year. For inner ring area, the traffic operation index of 4.7 in the morning and evening peak hours. The peak hour traffic operation index of the whole day is 5.6, which is in congestion state. In the morning and evening peak hours, the proportion of congestion mileage is 10.2%, increased by 0.9% yearly.

Table 12 Regional operation indicators within the main urban area and the inner ring area

Area	Morning/evening peak operation index	full-day peak hour traffic operation index	Morning/evening peak speed （km/h）	Peak hours the proportion of congestion mileage
Main urban area	4.2	4.9	23.1	6.7%
Inner ring area	4.7	5.6	20.7	10.2%

Data source: 2017 Chongqing Urban District Traffic Development Annual Report

4.3.4 Environmental pollution

Automobile exhaust

In 2010, a total of 45,554 vehicles were tested for exhaust emissions in Chongqing main urban area, including 29,618 gasoline vehicles and 15,936 diesel vehicles. The pass rates were 94.9% and 88.9% respectively. Most diesel vehicles were trucks. It can be seen that there is still a certain gap between the exhaust gas emission compliance rate of trucks from the overall level of vehicle exhaust emissions. Trucks with unqualified exhaust emissions entering the main urban area will inevitably increase the pollution level of the main urban area.

Noise pollution

According to data of 2016, the equivalent sound level of environmental noise in the main urban area of Chongqing is 53.3 dB, down 0.3 dB yearly. The traffic noise accounts for 8.8%. Through the noise monitoring of 158 sections with a total length of 533.89 km, the average equivalent sound level of daytime noise is 67.1 dB, down 0.2 dB yearly. According to the standard of noise classification, road traffic noise has reached a Noisy Level, which is ten dB higher than the ambient noise of the entire area. Most of the trucks use diesel engines, which noise is larger than that of gasoline engines. Moreover, when trucks (especially heavy vehicles) driving on the steep slopes, wind noise and whistle are much higher than ordinary cars, which increase the noise level of the main city. Due to the restrictions on trucks during the daytime, the trucks noise disturbance at night became the resident complaints focus. Through effective truck management countermeasures and noise management measures, truck noise can be reduced, providing a quiet and comfortable living environment for local residents. According to the circular issued by Chongqing Environmental Protection Bureau, the current traffic noise management measures in Chongqing main city mainly include sound insulation screen construction, road noise reduction green belt, low noise road network reconstruction, and banned sign construction, etc.

4.4 Logistics public policy

Urban logistics public policy can be divided into national policy and local public policy.

4.4.1 National Policy

National macro-control policy has a huge impact on China's logistics industry. The central government plays the role of guide and planner. In 2018, the central government issued a series of policies and measures to support and guide the development of logistics industry. In October 2018, General Office of the State Concil issued *the Three-Year Action Plan for Promoting Transport Structure Ajustment 2018-2020*, which focus on the development of railway and waterway transportation. It proposed to enhance the **effective connection between different transportation modes**. It is expected that the **national multimodal freight volume** will increate by 20% annually.

In terms of tax rates, the State Administration of Taxation of Ministry of Finance stipulated that as of December 31, 2019, the land for commodity storage facilities leased by logistics enterprises will be levied at 50% of the applicable tax standard.

For the sustainable development of logistics, in response to the accelerating the reform of the ecological civilazation system, ten departments joinly issued *the Guide Opinions on Coordinating the Promotion of Environment-friendly Packaging in the Express Industry*.It is proposed that by

2020, the proportion of biodegradable environment-friendly packaging materials used in express delivery should be increated to more than 50%, and the packaging consumbles should be reduced by 10% on average.

There are many other logistics policies related to economy, environment, transportation, supply and demand were actively implemented. Pilot enterprises are encouraged to explore advanced transportation organization models such as multimodal transportation, hanging transportation, joint distribution, etc, which are promoted in urban distribution, cold chain logistics and other fields.

4.4.2 Local public policy

On the basis of national policies, Chongqing multicipal government has vigorously implemented the urabn implementation plan. In June 2020, *the Implementation Plan of Chongqing logistics Comprehensive Reform Pilot Program for Cost Reduction and Efficiency Enhancement* was released. The pilot objectives are established, which are forming a convenient and efficient channel operation organization mode, making breakthrough in the innovation of service rules for multimodal transport, making improvement in the informatization of logistics, establishing a economical and intensive logistics land use and supply system, improving the customs clearance facilitation and logistics efficiency. In the meanwhile, the comprehensive transport costs of China-Europe freight trains and the western rail-sea intermodal trains should be decreased, while the waterway efficiency should be improved. The ratio of total social logistics expenses to GDP in the city was reduced by more than 1 percentage point compared with that in 2019. The sense of gain for the corporates should be obviously enhanced.

4.4.3 Policy classification

The logistics policy includes direct and indirect policy. Direct policy refers to the policy issued directly for the logistics industry and acts directly on it. Indirect policy refers to the policy made by government for other non-logistics fields and has indirect effects on the logistics industry. Through the behavior analysis of the participants, the logistics policies can be divided into the following three categories:

1) Social and economic logistics policy

The social and economic logistics, such as investegates policy and logistics talents introduction policy, can make the input-output ratio more reasonable and make more economic benifits. Taking investment policy as an example, the public nature of logistics infrastructure determines that the government should undertake part of the construction and investment tasks. In the early stage of the development of the logistics industry, the state and local governments directly invested to the logistics industry infrastructure. However, with the rapic development of social economy, the demand for transportation infrastructure is getting higher and higher. On the one hand, the increasing investment demand increases the government financial pressure, on the other hand, the diminishing marginal benefit leads to the decrease of investment benefit, so it is necessary to find new investment channels to meet the development and construction needs of the logistics industry.

2) Enviornmental logistics policy

The enviornmental logistics policy includes the new energy policy, night delivery policy, traffic restriction policy, energy conservation and emission reduction policy, etc. Excessive packing and low recycling rate in the logistics inductry bring about a large number of problems. The rapid increase in the number of motor vehicles has led to a sharp rise in the concentration of particulate matter in the air, causing air pollution. The construction of urban roads and other infrastructure encroaches on land. The reduction of urban vegetation area will not only destroy the original ecological balance, but also cause irreversible negative effects on water resources. The environmental logistics policy is aimming to ensure the sustainable development of economy. The pollution caused by the development of logistics industry should be controlled within the scope of environmental carrying capacity.

3) Supply and demand logistics policy

Supply and demand policies include standardization policies, government land policies, tax policies and so on. For example, a slight change in tax policy will directly affect the net profit of logistics enterprises and indirectly affect market supply.

4.5 Crux and challenges

Generally speaking, Chongqing's logistics market has great development potential. The scale of the industry would maintain long-term growth. Industrial structure is developing in the direction of intensification, specialization, and large-scale. However, given to the evaluation standards of **economic development, corporate profitability, and urban competitiveness**, the following **issues and challenges** of the industry can be summarized.

4.4.1 Shrinking of global trade volume and logistics demand

The continuous growth of trade volume is the basic prerequisite for the stable development of the logistics industry. However, since 2015, the global economic growth has slowed down, the global trade volume has shrunk, and the foreign trade demand of various countries has declined. Especially since the new crown pneumonia epidemic, international trade demand has shown a cliff-like decline. It has a great impact on an export-oriented economy like Chongqing, leading to **significantly drop on foreign trade logistics demand**. Before 2010, Chongqing had a weak logistics foundation due to the characteristics of the mountain city, which had a certain impact on the development of the logictics industry. However, in recent years, the invest in Chonqing's transportation infrastructure is heavy, and its logistics transportation capabilities have improved rapidly. The "One Belt One Road" policy promotes the construction of the international logistics channel and the "Three Rings, Ten Ray and Three Links" transportation network layout completed under the "Thirteenth Five-Year Plan", which greatly imporves the transportation and logistics infrastructure of Chongqing and is sufficient to support the continuous development of international and domestic logistics demand. However, the decline in trade volume in recent years has caused intermittent **excess of transportation capacity**.

4.4.2 Scattered corporations & lack of modern technology

The misunderstanding of logistics as an emerging third source of profit has caused many companies to be unwilling to lose control over purchasing and sales, and unwilling to seek out logistics services. As a result**, the third-party and fourth-party logistics companies in Chongqing take a less proportion**, while the first and second party logistics behaviors account for a relatively large proportion. According to a sample survey of the supply and demand situation of the logistics market conducted by Chongqing Logistics Association, the third-party logistics accounted for 9.1%, 16.1%, 21% from 2017 to 2019. Currently, there are only 60 third-party logistics companies that can provide integrated basic services such as warehousing and distribution, accounting for less than 25% of the market. This proportion in developed countries can reach more than 80%.

The lack of a large number of third-party and fourth-party logistics companies makes it **difficult to improve the logistics efficiency, professionalism, and reasonable allocation of resources** in Chongqing. Due to the small scale of the company, there **is no sufficient funds to purchase new and advanced equipment, to build information systems, and to introduce advanced management experience**. As a result, the overall mechanization, informatization, and automation of Chongqing's logistics industry are relatively low, and the load-bearing capacity of delivery vehicles and the automated processing mode of the transportation link are not perfect. The three-dimensional warehouse has not been built, and manual picking is still common in the distribution center. In the meanwhile, the cold chain facilities are backward, and there are few companies providing cold chain professional services. In particular, under the new challenge of higher cold chain temperature control requirements for vaccine transportation during the epidemic, **the lack of logistics capabilities** has been highlighted.

4.4.3 Shortage of senior logistics talent

Due to the late start of China's logistics industry**, the education** of professional talents and senior talents in the logistics industry **is relatively backward**. In addition, companies do not require much professional knowledge of logistics talents, which leads to the **general shortage of senior technical talents** in the logistics industry. Fetterd by traditional concepts, some high-level and intermediate-level logistics talents choose to work in Beijing, Shanghai, Guangzhou and Shenzhen. **Relatively low wages and lack of other supporting facilities** have become Chongqing's shortcomings in attracking middle and senior logistics talents. At the same time, the **qualification certification of logistics professionals** has not yet formed a complete system. The employees of logistics enterprises, **lacking of professional training and guidance**, have different level of knowledge and skills of logistics business, greatly affecting the professional service capabilities of logistics enterprises.

4.4.4 Severe congestion in the main urban area

An important part of urban logistics is urban logistics distribution, and **the "last mile" distribution** is an important issue in Chongqing due to its severe congestion in the main urban area. According to the analysis of Chongqing's background research and logistics development status, there are many reasons for the severe congestion: 1) Due to the **special topographical features** of Chongqing, urban planning is more dispersed, forming a layout structure with multiple centers and fragments. There are often many **bridges connecting the tunnels**, which limits traffic flow. 2) Chongqing had a large number of wholesale markets in its early years. These **wholesale markets** were built earlier, **mostly in the downtown area**, and far from the logistics center, which greatly increased the demand for freight in the urban area. 3) The main urban area **is densely populated**, it is a gathering place for production and consumption, and it is also the most active place for Chongqing's logistics. In recent years, the number of private cars in Chongqing has increased sharply, and since the emergence of e-commerce, there have been a large number of express delivery services in urban areas. The increase has greatly **increased the demand for traffic** in the urban area.

4.6 Chapter summary

Based on the theoretical analysis of the composition of urban logistics system in Chapter 3, this chapter has conducted in-depth research and analysis on the logistics system of Chongqing, including the basic elements of logistics materials, participants and environmental factors.

In terms of the basic elements of materials, due to the unique location and geographical characteristics of Chongqing, and the historical legacy of urban development imbalance, Although the planning of Chongqing's logistics nodes is gradually enriched, the construction of the node is late, and it is still in the stage of extensive expansion. There is still a certain gap between the function and the modern logistics park. Although Chongqing is the only transportation hub in the west with three transportation modes of water, land and air, the four modes of transportation of waterway, railway, highway and aviation are unbalanced, relying too much on road and waterway transportation. In addition, Chongqing logistics information platform and new technology equipment The development also lags behind the national average. In terms of participation, the paper analyzes Chongqing's logistics demand, supply and supervision subjects. In terms of environmental factors, the economic, social, transportation and environmental pollution situation in Chongqing was analyzed. Based on the above three parts of the survey and analysis, it summed up the crux of logistics development in Chongqing, including the lag of the development of logistics infrastructure, the difficulty of distribution in the last mile, and the lack of senior logistics talents.

The logistics system in Chongqing is comprehensively investigated and analyzed in this Chapter. It lays the foundation for the structure and parameter design of the SD model in Chapter 5, making the model closer to the real situation and realistically simulating the logistics problem in Chongqing.

5. SD Model and Policy analysis

In this chapter, a **system dynamics** (SD) model is built focusing on Chongqing **logistics system**. **Economic, social, transportation and environmental conditions** are considered as components of the model. The objective is to meet **the optimal of the whole system**. With the simulation of SD model, **effective initiatives** are explored for improving the development of logistics industry, promoting economic development, reducing logistics external uneconomicality, and improving urban competitiveness.

5.1 System analysis

This section establishes the system hypothesis, determines the system boundary, sets the system KPI, analyzes the system causality and feedback relationship, and provides basis for the construction of SD model. The system hypothesis simplifies the complex problem, making it possible to model high-dimensional complex objects. The system boundary defines the boundary for the model, and focuses the model on the problem to be solved. The system KPI provides evaluation indicators for the model, in order to transform the logistics system development into a quantifiable contrast indicator, to better judge the effectiveness of the policy. The analysis of system causality and feedback directly paves the way for building a system model.

5.1.1 System hypothesis

The system has following assumptions.

(1) Since the urban freight demand and freight capacity directly reflect the urban logistics situation, in this paper, the logistics annual freight demand (10,000 tons) is quantitatively substituted as the logistics demand, and the actual annual freight volume is used as the quantitative indicator of the actual logistics situation. As for the rest factors such as warehousing situation, high-tech, information services, since it is difficult to obtain and measure statistical data, quantitative calculation is not carried out in the model. The factors are only used as the influence coefficient of logistics supply capacity (cargo capacity).

(2) According to the calculation based on the annual report on traffic development of Chongqing main city, the proportion of trunk roads and branch roads in Chongqing main city area basically remained unchanged for 10 years. So in this paper, it is assumed that the growth of Chongqing trunk roads and branch roads always maintains a certain proportion, which is the average growth value over 10 years.

(3) It is assumed that Chongqing logistics industry total fixed assets investment linearly related to the urban GDP development. It is assumed that the social fixed assets investment in logistics industry is all used for logistics nodes, urban rail freight, waterway freight, air cargo expansion and highway construction, while all the investment in freight vehicles comes from the self-investment of logistics companies.

(4) NO2 and PM2.5 are the main pollutants emitted by automobile exhaust. This paper assumes that the ratio of main pollutants (including NO2 and PM2.5) to urban capacity can reflect the overall environmental pollution level of the city.

(5) Chongqing mini-trucks permit lifetime is 12 years, while other types of trucks have a lifetime of 15 years. In order to simplify the model, this paper assumes that the life cycle of trucks is 14 years, and trucks over 14 years are automatically scrapped.

(6) The utilization of high technology and the development of information platform means there is a large one-time cost in the early stage, and the equipment maintenance needs to be invested in the later stage. At the same time, high-tech and information platforms can improve work efficiency and reduce logistics costs to a certain extent. Therefore, it is difficult to determine the combined impact of high-tech and information platform applications on logistics costs. This paper assumes that the logistics cost ratio is a constant over a period of time. Taking the total revenue of the logistics industry in the input-output table in 2015 minus the surplus of the logistics industry as the total cost of logistics, and the ratio of cost to total revenue can be calculated.

(7) It is assumed that the ratio of the total amount of remuneration paid and tax by the logistics company to the amount of income is a fixed value.

(8) It is assumed that the logistics distribution market price is only affected by the market supply-demand ratio. When the market logistics supply is greater than the demand, the logistics distribution price will float downward by a certain percentage on the benchmark value. When the supply is less than the demand, the delivery service price will float upward by a certain percentage on the benchmark value.

(9) Since it is difficult to calculate the absolute value of the distribution benchmark price, it is assumed that the city distribution benchmark price is the ratio of the total logistics revenue to the total freight volume.

(10) It is assumed that the annual investment in freight vehicles by logistics enterprises is only affected by their own surplus and the market distribution supply-demand ratio. It is assumed that the investment amount of trucks accounts for a certain proportion of the enterprise surplus. The proportion floats upward or downward, depending on the supply-demand ratio of the year.

5.1.2 System boundary

The key to analyzing a system dynamic behavior is to understand and master the system structure. The first step in determining the system structure is to delineate the system boundaries, based on the modeling purpose and the operational mechanism of the actual problem, in order to determine the endogenous and exogenous variables of the system. According to the modeling purpose in this paper, the following **main factors** are included.

(1) **Urban logistics demand**, including total annual logistics demand, annual freight demand, annual urban distribution demand

(2) **Urban logistics supply capacity**, including trunk freight capacity, logistics node operation capacity, urban distribution capacity, logistics equipment and information technology impact factors (IF), public information platform impact factors (IF)

(3) **Supply and demand balance relationship**, including: actual annual freight volume, total logistics shortage, supply-demand ratio, supply-demand ratio premium coefficient (coef)

(4) **Terms of economic factors**, including urban GDP, logistics promotion factors on production value, logistics shortages hinder factors on economic development, logistics industry total social fixed assets investment

(5) **Social factors**, including immigration rate, urban resident population, logistics labor supply, logistics employment, logistics labor shortage

(6) **Traffic factors**, including passenger vehicle turnover, freight vehicle turnover, road traffic carrying capacity, traffic congestion level

(7) **Environmental factors**, including the number of freight vehicles, truck contribution rate to pollution, truck average annual emissions, and environmental pollution level

5.1.3 Model KPI

The goal of logistics policies is to improve the development level of logistics industry, avoid logistics shortage, promote urban economic development, and at the same time ensure a good environment and traffic capacity, reduce the external uneconomic of urban logistics, achieve the overall system optimization, and improve urban competitiveness. According to the **three system evaluation criteria** of urban logistics proposed in Chapter 3 (to meet the needs of economic development, meet the surplus needs of enterprises, and meet the needs of urban competitiveness), the KPI of this model is set as follow.

(1) Urban logistics total annual shortage

(2) Actual city freight volume

(3) Distribution company surplus

(4) The number of logistics jobs

(5) Degree of environmental pollution

(6) Degree of traffic congestion in the main city

5.1.4 Casual loop diagram

Considering the development of urban logistics system, together with direct and indirect relationship with urban economy, society, environment, and transportation, the system causal relationship diagram is constructed as shown in Figure 21.

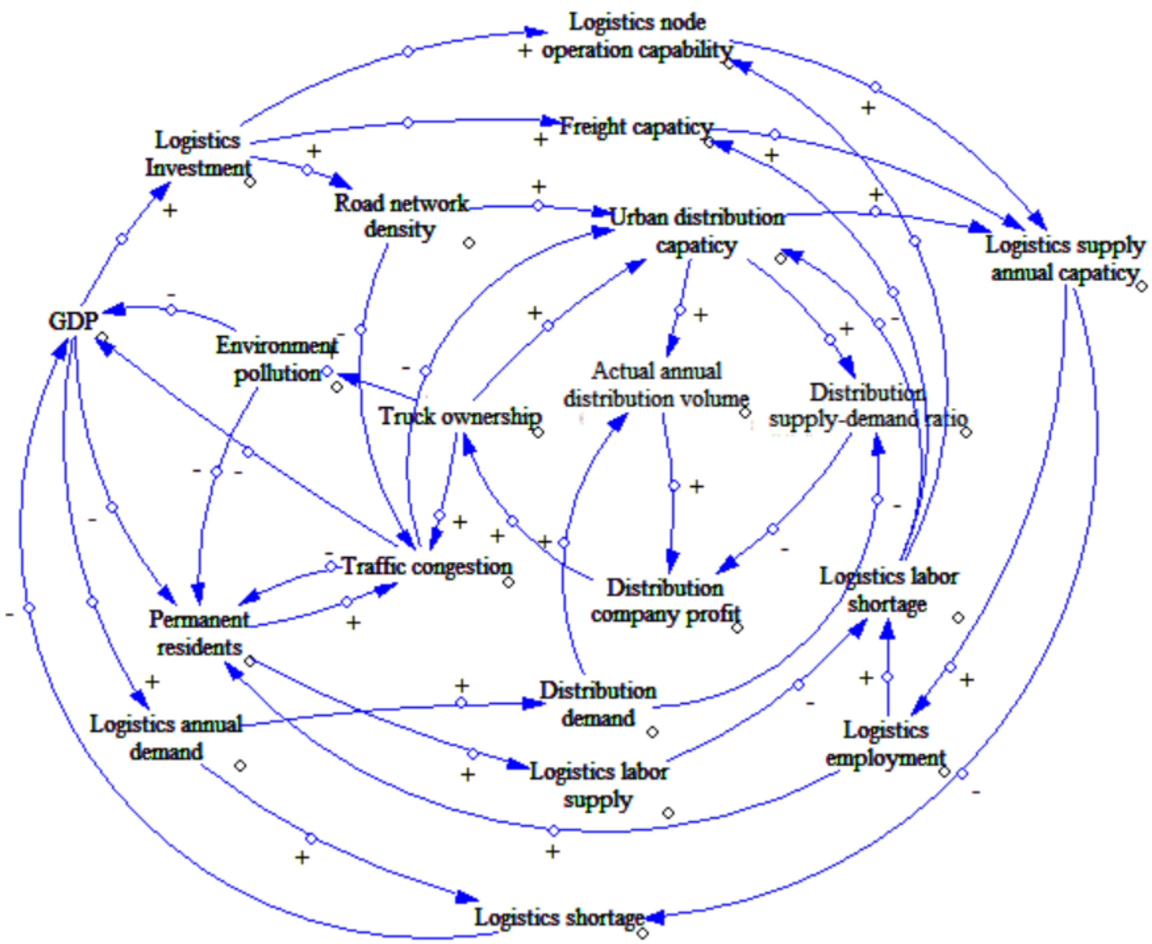


Figure 21 Urban logistics system causity relation diagram

The loops included in the causality loop diagram are as follow.

(1) GDP→Investment in Logistics→Logistics node operation capability/Freight capacity/Urban distribution capacity→Logistics supply annual capacity→Logistics shortage→GDP.

This **positive feedback loop** indicates: urban economic development and social wealth accumulation promote investment in logistics infrastructure construction. The capacity of logistics node, urban freight and urban distribution will be improved by investment in the extension of freight hub, logistics park, logistics center, freight transportation. Furthermore, city's total logistics supply capacity will be improved, which can alleviate the shortage of urban logistics, and promote economic development. Thereby a positive feedback loop is formed.

(2) GDP→Logistics annual demand→ Logistics shortage→GDP.

This **negative feedback loop** indicates: urban economic development will increase annual total logistics demand. Assuming that the logistics supply capacity is unchanged, the logistics shortage will increase, which will hinder the development of the urban economy and form a negative feedback loop.

(3) Resident population→logistics labor supply→logistics labor shortage→logistics node operation capacity / transportation capacity / city distribution capacity → total logistics supply capacity → logistics employment→ resident population.

This **positive feedback loop** indicates: the increase in the resident population of the city will lead to an increase in the supply of logistics labor, ease the shortage of urban logistics labor, and improve the total annual supply capacity logistics, thereby generating more jobs in the logistics industry and increasing the employment opportunities in the city. It will increase the attractiveness of the city to the foreign population, thus further increasing the resident population, forming a positive feedback loop.

(4) Resident population→traffic congestion→immigration rate→resident population.

This **negative feedback loop** indicates: the increase of the resident population of the city will increase traffic flow, thereby increasing traffic congestion, and traffic congestion will reduce the attractiveness of the city to foreign population, thereby reducing the immigration rate and reducing the resident population, forming a negative feedback loop.

(5) Resident population→traffic congestion→urban distribution capacity→total annual supply capacity of logistics→logistics shortage→GDP→resident population.

This **negative feedback** indicates that the increase in the resident population of the city will increase traffic congestion and reduce the annual transportation capacity of the vehicle, thereby reducing the urban distribution capacity and the total annual supply capacity of the logistics, aggravating logistics shortage, hindering the urban economic development. The slowdown of urban economic development will further reduce the attractiveness to foreign population and form a negative feedback loop.

(6) Truck ownership → city distribution capacity → actual annual distribution volume → distribution enterprise surplus → truck ownership.

This **positive feedback loop** indicates that the increase in the number of urban trucks will increase the city's distribution capacity, resulting in an increase in actual annual distribution and an increase in corporate surpluses, thereby allowing more funds to invest in freight vehicles and forming a positive feedback loop.

(7) Truck ownership → city distribution capacity → ratio of distribution supply and demand → distribution enterprise surplus→truck ownership.

The **negative feedback loop** indicates that an increase in the number of urban trucks will increase the city's distribution capacity. Assuming that the distribution demand is constant, the supply exceeds the demand, resulting in a decline in the price of logistics services on the market. Assuming that the actual annual distribution is unchanged, the surplus of the distribution company is reduced, so that the number of trucks will decrease, forming a negative feedback loop.

(8) Truck ownership → environmental pollution → resident population → logistics labor shortage → urban distribution capacity → actual annual distribution volume → distribution enterprise surplus→truck ownership.

This **negative feedback loop** indicates that the increase in the number of trucks will increase the degree of environmental pollution, reduce the city's attractiveness to foreign population, increase the labor shortage in the logistics industry, weaken the city's distribution capacity, reduce actual annual distribution and reduce distribution company surplus, thereby reducing the increase speed of the truck and forming a negative feedback loop.

(9) Highway network density → traffic congestion → GDP → logistics industry investment → road network mileage.

This **positive feedback loop** indicates that the increase of road network density will alleviate traffic congestion, promote urban economic development, increase investment in logistics industry, and further promote the increase of road network density, forming a positive feedback loop.

5.2 Stock Flow Diagram

The causal loop diagram depicts the **relationship among various parts of the logistics system** in Chongqing. According to the feedback relationship it depicts, the stock flow diagram can be drawn to further **quantify the causal relationship**. The variables in the stock flow diagram include Level, Rate, Auxiliary, and Constant. This paper divides the model into **five subsystems**, which are urban logistics supply & demand subsystem, urban logistics-economic subsystem, urban logistics-social subsystem, urban logistics-environment subsystem, urban logistics-transport subsystem. The subsystem flow diagrams are shown in *Appendix Figure 1* to *Appendix Figure 5*.

5.2.1 Supply & demand subsystem

The urban logistics subsystem contains eight state variables, namely, logistics node operating capability (LNOC), railway transportation capacity (RTC), waterway transportation capacity (WTC), air transportation capacity (ATC), road transportation capacity (RTC), road mileage (RM), truck ownership (TO), distribution entity surplus. Correspondingly, there are 11 rate variables, and the rest are auxiliary variables. The submodel is included in *Appendix1*.

The urban logistics supply & demand subsystem studies the **supply and demand relationship of urban logistics**. The submodel simulates the freight supply capacity, freight demand, logistics shortage, as well as the supply and demand ratio. Through the internal regulation of logistics supply and demand ratio and service price level, the logistics supply & demand balance and a balanced development mechanism of different elements of logistics supply are constructed. This submodel calculates the annual logistics demand according to the correlation between urban logistics demand and urban GDP. The detailed calculation formula will be introduced in the *Appendix2*. The coefficients of logistics demand are retained, so that **different demand scenario can be simulated**. The **supply capacity** of urban logistics system mainly includes **three parts**, namely, **urban cargo trunk transportation capacity, logistics node operation capability and urban distribution capability**. Since the model uses freight volume as an indicator of quantitative input value, the freight volume of trunk transportation and urban distribution in Chongqing logistics system can better reflect the development of the system. Therefore, trunk transportation and urban distribution are set as major parts of logistics supply & demand subsystem. Logistics node, logistics equipment tool, development of the information platform and other parts are treated as impact factors on freight capacity.

Urban cargo trunk transportation includes the transportation of the railway, waterway, aviation and highway trunk lines. The speed of development depends on **government plan**, **total social fixed assets investment** and **investment benefit factor**. Meanwhile, the **operational efficiency of transportation service providers** and **transportation equipment** will also affect the capacity of trunk transportation. In order to simplify the model, the three-level logistics nodes of Chongqing Logistics Network are simulated with a state variable "**logistics node operation capability**" in this paper. The government can regulate the balanced development of logistics nodes and urban freight transportation by **changing the investment ratio** of logistics nodes and transportation trunks and urban highways. In the model, the "**urban freight and logistics node capacity ratio**" variable **monitors the development of urban freight and logistics nodes**. If there is a serious imbalance, the government behavior will be simulated and the investment ratio of logistics nodes and freight will be changed. However, the government's regulation has a certain lag, so the corresponding "**investment delay**" variable is used in the model to simulate this regulation lag.

The **ability of urban distribution** depends on the **truck ownership**, **vehicle utilization** and **vehicle annual transportation capacity**. According to the assumptions of this model, the investment of trucks comes from the **self-investment of the distribution company**. The self-investment amount of the distribution company depends on the difference between the income and cost of the company, that is, **the profit of the company**. Vehicle utilization value is between 0-1, depending on the development of the logistics industry market, government regulations and restrictions on trucks. It is set as an external input constant in the model. It can **be changed to observe the sensitivity of the model KPI to vehicle utilization**. The annual transportation capacity of the vehicle indicates the annual **freight volume of the average unit truck**, which is affected by the **average load, driving speed, loading rate, loading and unloading time, transportation distance, and freight time window**. The shortage of urban distribution will increase **urban distribution prices**, and the urban distribution price and the actual distribution amount together determine the **income of the distribution company**. In addition, the logistics supply&demand subsystem also considers **the impact of labor shortage** on transportation capacity.

5.2.2 Economy subsystem

Urban logistics-economy subsystem includes three state variable, which are gross output value of primary industry, second industry and third industry. Correspondingly there are 6 rate variables, and the rest are auxiliary variables. The submodel is included in *Appendix1*.

The logistics-economic subsystem modeled and simulated the development of the three industries in the city. The **industry coefficient** was retained in the model to change the growth rate of each industry. By **changing the coefficients, different urban economic development scenarios can be simulated**. In addition to the **self-growth coefficients** of each industries, the model also considers the **promotion** to the economic development caused by development of the logistics industry, and the **obstacles** to the economic development caused by logistics shortage. According to the **correlation between GDP and fixed assets**, the fixed assets investment in logistics industry is calculated.

5.2.3 Society subsystem

The social subsystem contains two state variables, the permanent resident (PR) and the logistics labor supply (LSS). Correspondingly, there are 4 rate variables, and the rest are auxiliary variables. The submodel is included in *Appendix1*.

The social subsystem mainly considers the population change of the city and the impact on the **labor supply capacity** of the logistics industry. Environmental pollution, traffic congestion, urban economic development, and logistics employment are regarded as the important factors influencing

urban attraction to talants. According to the difference between labor supply and employment position in the logistics industry, the **shortage of logistics labor** is analyzed as the output of the subsystem.

5.2.4 Environment subsystem

The environmental subsystem mainly analyzes the impact of **urban truck ownership** on urban environmental pollution. It contains two state variable, which are NO_2 content and inhalable particulate content. Correspondingly, there are four rate variable and the rest are auxiliary variables. The environmental subsystem estimates the NO_2 and inhalable particulate content based on the **cargo vehicle ownership** and calculates the **environmental pollution level** as the output of the subsystem. The submodel is included in *Appendix1*.

5.2.5 Transportation subsystem

The traffic subsystem mainly analyzes the impact of urban freight vehicles, economic output value, resident population and highway route mileage on **urban traffic conditions**. **Road traffic load** is determined by both the **road traffic capacity** and **traffic intensity**. Since passenger vehicles are one of the main factors of urban traffic load, in addition to analyzing the **turnover of freight vehicles**, the system also analyzes the traffic load caused by **different passenger modes** in the city. The submodel is included in *Appendix1*.

5.3 Validity test

The usual model validity test is to compare with historical data. However, the SD model validity test includes not only a **comparison method of historical data**. It is to **verify whether the model is useful for a particular modeling purpose**. There are many different ways to verify validity for different modeling purposes. The three most common uses of the model are: 1) **exploring possible futures**; 2) studying the **impact of different policies** on model output; 3) studying **systems and the relationship between system structure and behavior**. The SD model validity test method can be divided into **three categories**: **Direct structure test**, **structure-oriented behavior test**, and **behavioral reproduction test**. Direct structure test is a direct check of the model structure before simulation. Structure-oriented behavior test is a method of indirectly checking the structure of a model. After running the model, **compare its behavior with the actual situation/expected behavior** to discover the error of the model structure. The behavioral reproduction test is a statistical comparison of the model output to the past behavior of the actual system.

The purpose of this paper is as follows: 1) Constructing **the internal structure of urban modern logistics system** through SD model simulation, and constructing the relationship between supply and demand of logistics system. 2) Simulating the **interaction between the logistics system of the city and the external environment**. 3) Find **effective policies and development strategies for the sustainable development** of urban logistics systems. Analysis of the purpose of this paper shows that this model **does not care about the re-emergence of historical data**, but focuses on the analysis of model structure and the link between structure and behavior, as well as the analysis of the effects of different policy measures, so **direct structure test** and **structure-oriented behavior test** are selected as validity test methods in this article.

5.3.1 Direct structure test

Direct structure test is the inspection of the model structure before running the model. The direct structure test made by this model includes 1) **Direct boundary adequacy test**, after the model is built, the system boundaries identified in *Section 5.1* are further examined to ensure that relevant factors and indicators are included within the system boundaries. 2) **Direct structure assessment test**, through the overall observation and research of the model, it is checked whether the model conform to the social law and natural law. 3) **Parameter/function confirmation test**, check whether the parameters such as constants and table functions in the model are consistent with the actual historical data. For parameters that cannot get historical statistics, check whether the variable equation in the model is reasonable.

5.3.2 Structure-oriented behavior tests

Structure-oriented behavior tests are to test the model behavior after running it. **Four specific methods** are selected in this paper. 1) **Base case testing**, checking whether the basic performance of the model is reasonable without changing the model parameters. 2) **Boundary adequacy test**, setting different running times, observing whether the model output can show the complete change cycle and trend, and trying not to waste computing resources under the premise of sufficient running time. 3) **Extreme conditions behaviour test**, setting the model parameters to extreme values and checking if the model output is reasonable under extreme conditions. 4)**Sensitivity analysis**, checking whether the model is too sensitive to a parameter, whether the model is in equilibrium.

Base case testing

The performance of the KPI in the **basic case of the model** is shown in the Figure 22. The data used as the initial value of the model comes from the *Chongqing Statistical Yearbook 2000*. The running time of the model is set to 80 years. Related changes of logistics industry and urban development in Chongqing during the 80 years are obtained through simulation calculation.

As can be seen from Figure 17, the simulation results predict that the total annual shortage of logistics in Chongqing will increase first and then decrease, and will reach a maximum around 2020. After that, it will decrease year by year, and **urban logistics shortage will be gradually eliminated**. The **actual total freight volume, logistics jobs and environmental pollution levels** have similar change trend. First it shows an **exponential growth**, and after 2050, it will continue to grow year by year, but the growth rate will **gradually slow down**, showing a **logarithmic growth trend**. The **surplus of distribution companies first increase linearly**, and after 2050, it will turn to **logarithmic growth**. The simulation results show that the **traffic congestion** in the main city **has decreased year by year** from 1999 to 2004. After 2004, the **congestion situation has gradually increased, which is consistent with the actual situation**. After that, the simulation expects that the congestion will **gradually ease** after 2027.

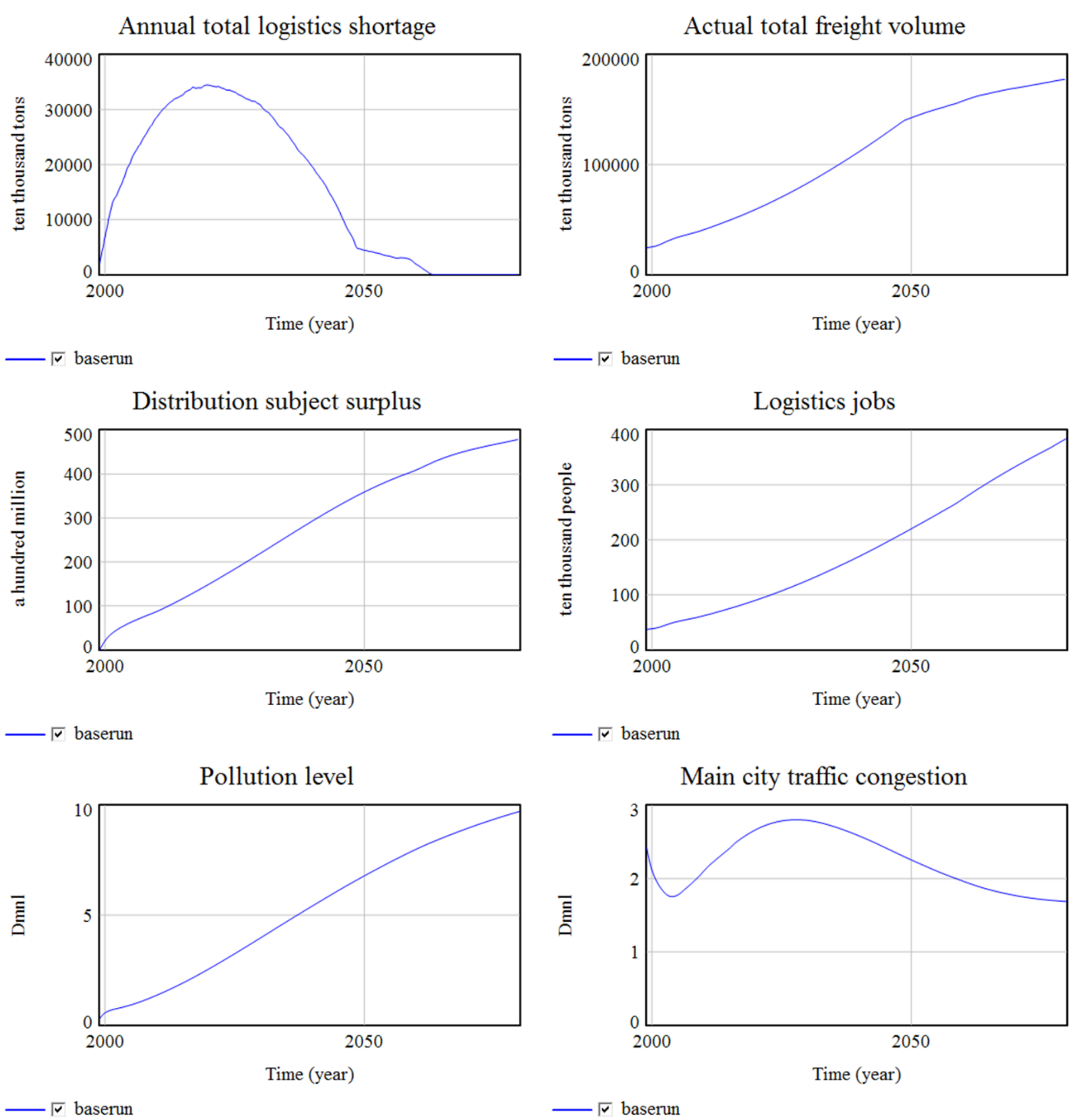


Figure 22 KPI behaviors of the SD model base run

Boundary adequacy test

The running time set by this model is 80 years. To verify whether the selected runtime is sufficient to **reflect all key performance of the KPI without wasting computing resources**, the running time was set to 100 years. The performance of the six KPIs is shown in Figure 23. It can be seen that the first 80 years have basically covered all the important changes of the KPI. Through the first 80 years, it has been enough to see all the important changes in the development of urban logistics freight. At the same time, since the real system is much more complex, there may be various unexpected events that have an unpredictable impact on the actual logistics system. Therefore, under the condition that all important changes can be included, a shorter time period is selected for simulation.

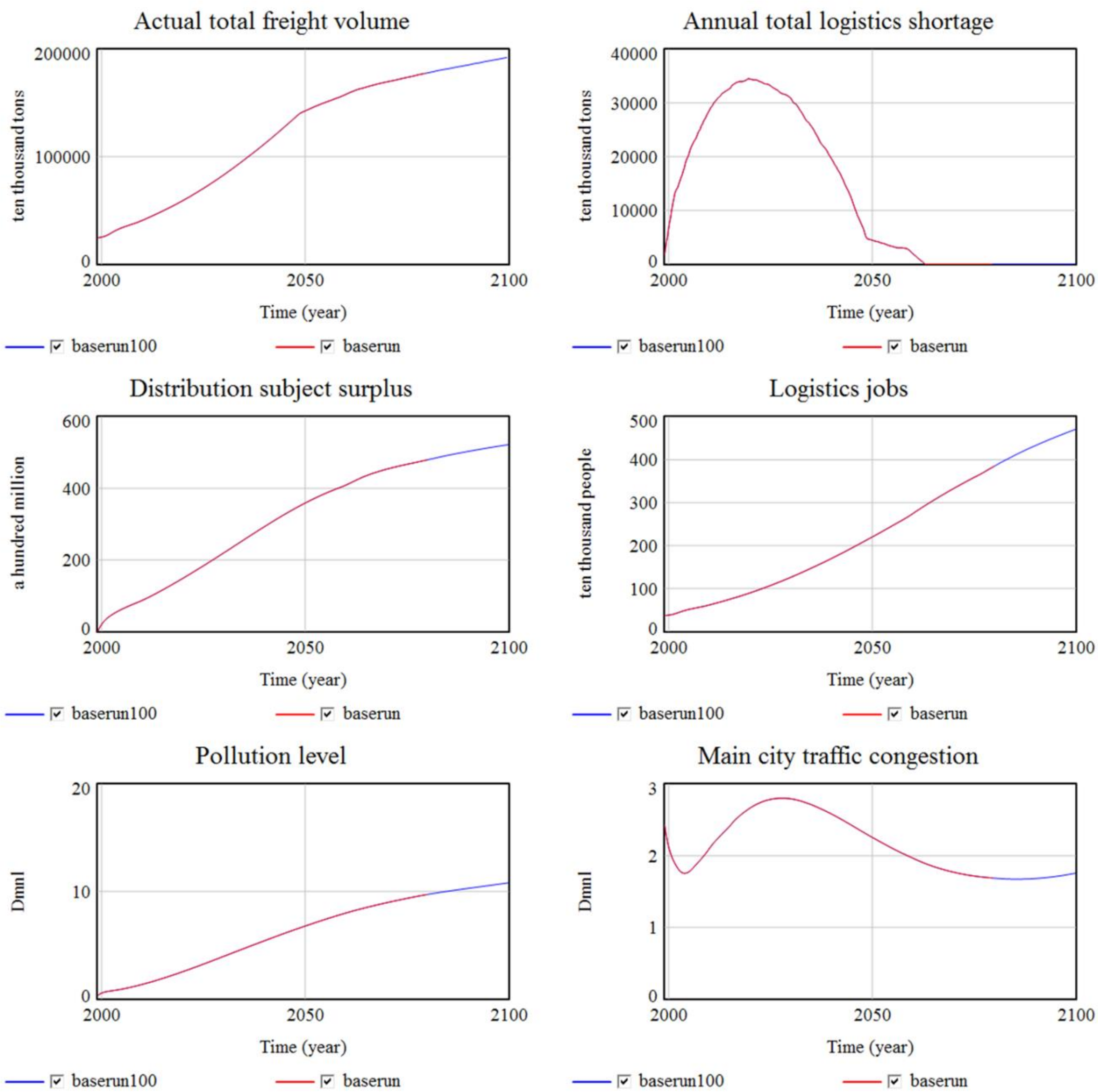


Figure 23 KPI behaviors of the model boundary adequacy test

Extreme condition behaviour test

The extreme condition test will leave the model in an extreme situation and observe whether the simulation results of the model meet reasonable expectations. The extreme situation of "**no investment**" in the whole society is simulated in this model, and the benchmark value of freight investment and fixed assets investment related to logistics industry are set to zero. Thus, in this scenario, since 1999, the government, community and logistics companies all provided no investment in the development of logistics. The model simulation results is shown in Figure 24.

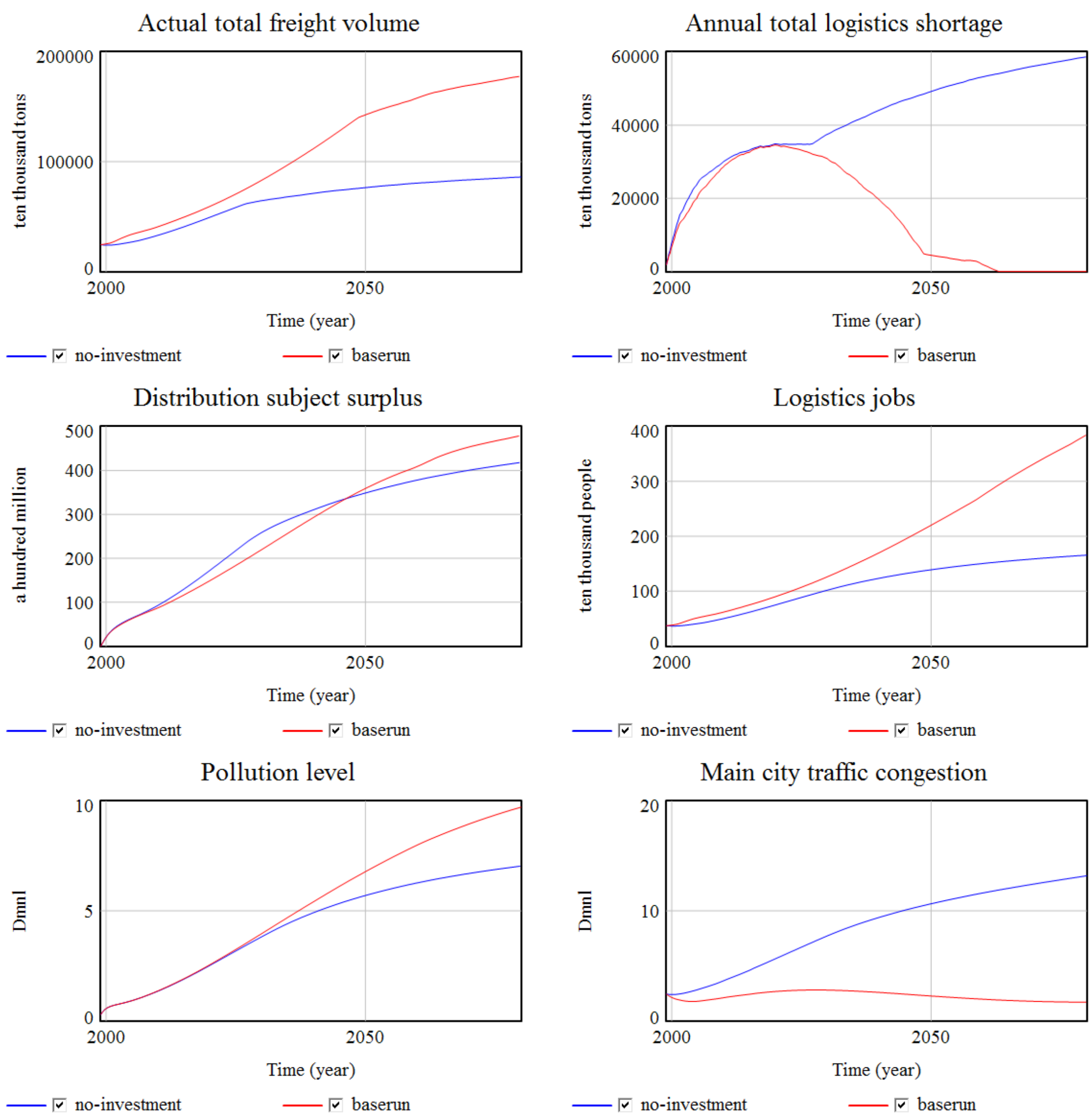


Figure 24 KPI behaviors of the model extreme condition test

It can be seen from the simulation results that the actual total freight volume of the city is slowly decreasing. The shortage of logistics first increased rapidly, and then gradually slowed down. The first rapid growth of the logistics shortage is because the logistics supply capacity of the city was in a relatively backward stage in 1999, and there is no investment in logistics industry. The original trucks and other logistics materials are gruadully consumed, which will further reduce the logistics supply capacity. Thus, the shortage of logistics in the first phase increases rapidly. The logistics demand for urban economic activities is not satisfied, which seriously affects the economic activities of the city. Since the shortage of logistics obstacles the urban GDP growth, the demand for logistics in the city is gradually decreasing, which makes the growth rate of logistics shortage slow down.

Since there is no self-investment of logistics companies, the number of trucks should decrease year by year (existing trucks are gradually reduced due to the time limit). Therefore, traffic congestion in the main city has improved in the long run. However, due to the lack of investment in urban road construction, the density of urban road network has not increased. Moreover, the amount of travel of urban residents has not decreased, making traffic congestion in the early stage more serious than in normal investment situations. The extreme conditions of no investment can basically be regarded as the situation in which the city stops developing. It can be seen that urban environment has also been greatly improved. But it should be emphasized that this model only considers the impact of the logistics industry on the environment. Therefore, the simulation results of environmental pollution do not represent the actual situation of the entire city, but only part of it which is caused by logistics. The surplus of urban distribution companies also rises rapidly in the initial stage, and then its growth rate slows down. This is because in the first stage, the income of the distribution subject has not changed, and there is no investment, which makes the company's earnings increase rapidly, and this growth will gradually become zero due to the stagnation of the development of the urban logistics industry.

Sensitivity analysis

Sensitivity analysis is used to detect **whether the model is sensitive to small changes in a single or some input constant in the model**. The process of sensitivity analysis is to make small adjustments to the input constants, re-run the model, and observe whether the new model simulation results have large changes that do not meet expectations. Sensitivity analysis ensures that the model is **not in an unstable equilibrium state**, thus detecting the validity of the model.

Sensitivity analysis was performed on all input constants in this model, and no unreasonable performance was found. The analysis results of vehicle utilization rate, distance between logistics center and distribution terminal, and joint distribution are shown in the Figure 25-Figure 27. The input range settings are -0.1 to 0.1 of the respective initial values.

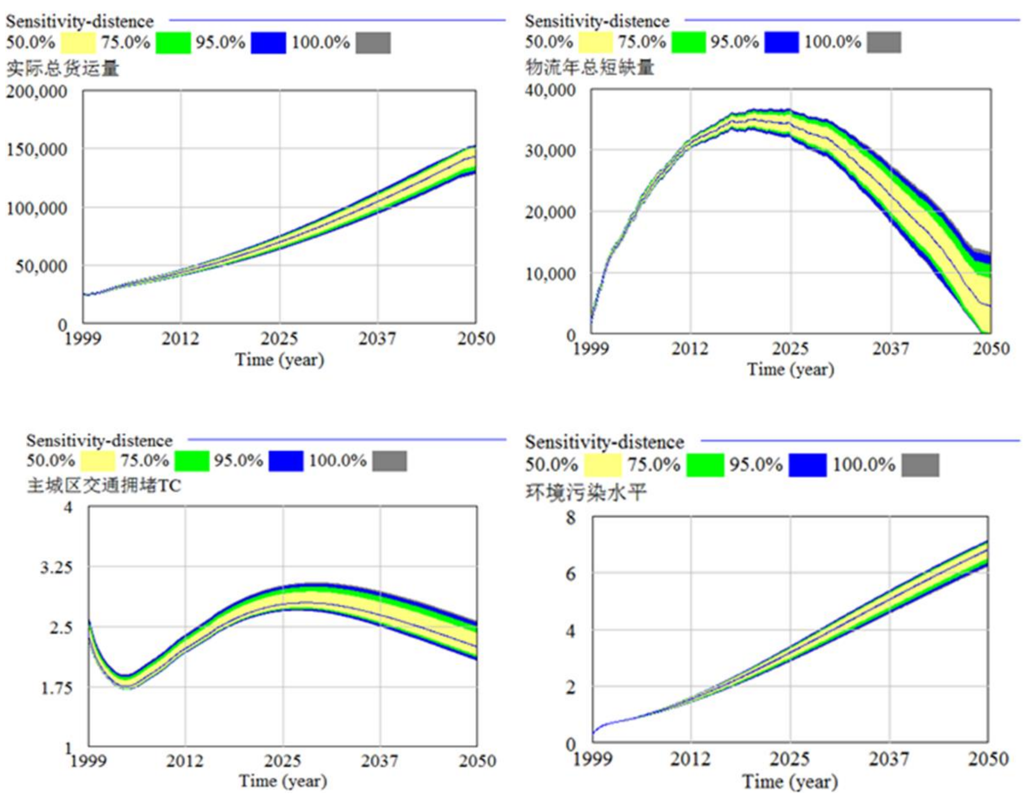


Figure 25 Sensitivity analysis of distance between logistics center and distribution terminal

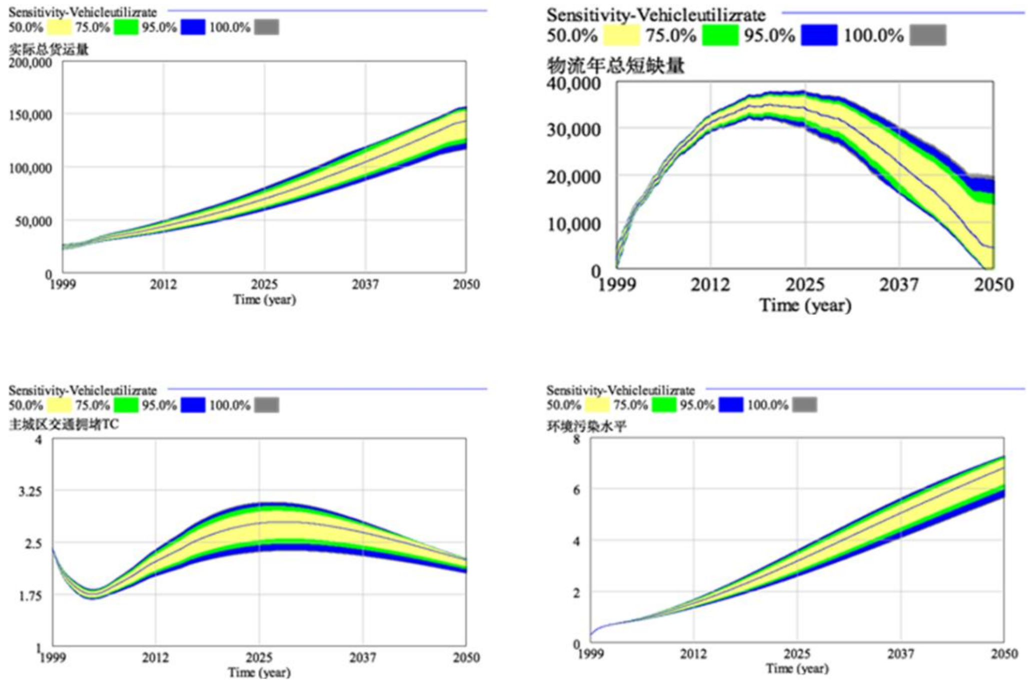


Figure 26 Sensitivity analysis of vehicle utilization rate

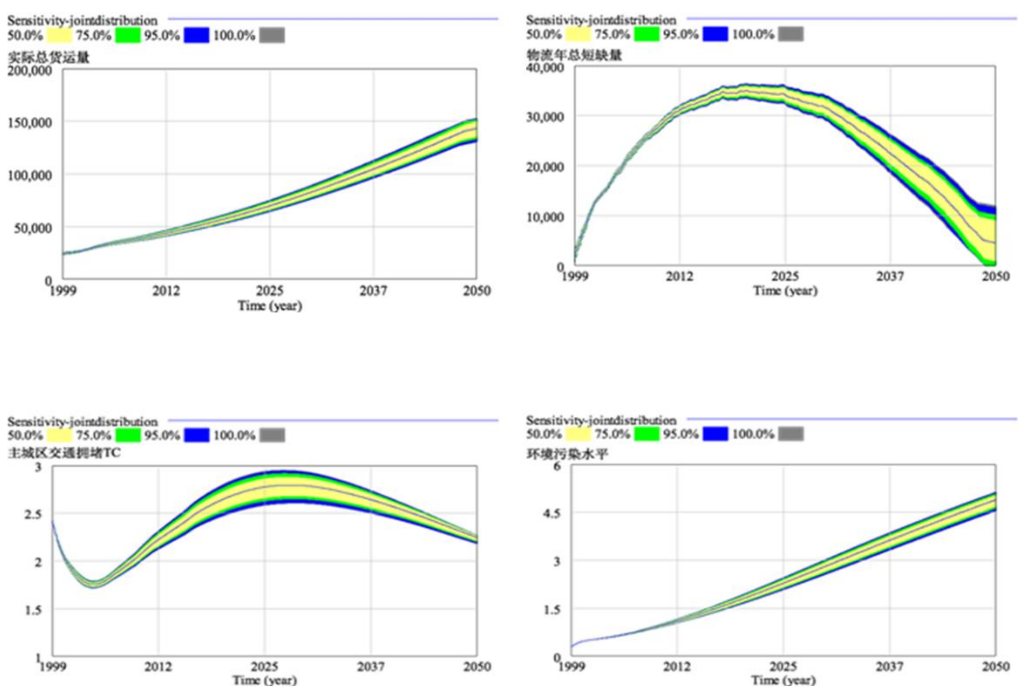


Figure 27 Sensitivity analysis of joint distribution

5.4 Policy analysis for Chongqing Logistics

System dynamics model can **simulate the impact of policies on system behavior** by changing certain policy-affected variables. While changing the value of the specified parameter, the other parameter variables of the system should remain unchanged. According to the analysis in Chapter 3 and Chapter 4, this chapter will simulate and analyze the impact of four aspects of public policies on the development of Chongqing's logistics industry, including stimulating trade growth, improving the modern service capabilities of logistics enterprises, guaranteeing logistics talents, and improving traffic congestion.

Promoting growth of trade demand

The trade demand in a city directly affects the logistics demand in it. In order to test the **impact of trade promotion policies** on the development of Chongqing's logistics, variables that control the changes in trade volume and logistics demand are constructed in the SD model, **simulating the KPI** changes in Chongqing under **different trade volume demands**. The simulation results are shown in Figure 28. It can be seen that promoting the growth of trade volume will increase the total annual shortage of logistics in the short term, but in the long run, it can effectively increase the actual total cargo volume, the surplus of logistics enterprises as well as logistics employment positions. It is conducive to the long-term development of the logistics industry. But it is also important to see that when environmental policies remain unchanged, the increase of trade volume and economic growth will also aggravate the environmental pollution of the city. Urban congestion levels will increase significantly by 2070 (comparing to the scenario that trade remains or decreases). After 2070, it will gradually reduce to the same level as under the constant trade volume scenario. Therefore, policies and measures to protect the environment and improve urban congestion should be implemented at the same time as increasing trade demand.

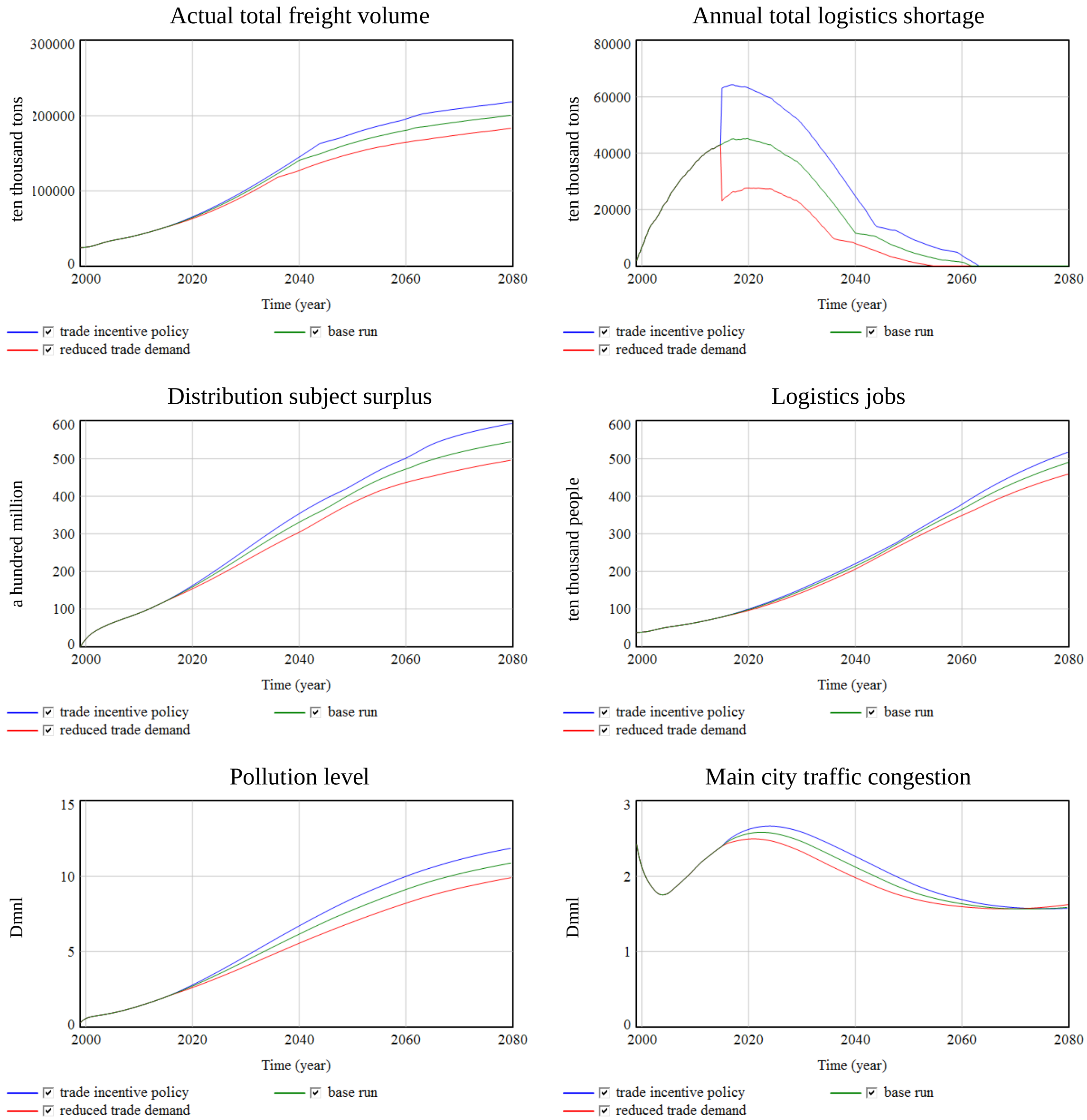


Figure 28 The simulation results of trade demand promotion policy

Improving modern service capability

In order to test the **impact of modern service capability promotion policies** on the development of urban logistics industry, a policy lever that can simultaneously control multiple factors related to modern service capability is constructed. The factors controlled in the model include the **degree of equipment technology development, operational efficiency influencing factor, the degree of development of public information platforms, the reference value of logistics service prices, the proportion of logistics costs, the degree of development of joint delivery, and the efficiency of vehicle utilization**. Chongqing's KPIs which changes under different development levels of logistics modern service are simulated by the model. The simulation results are shown in Figure 29. It can be seen that improving the modern service capacity of urban logistics can effectively and directly reduce the logistics shortage. There is also a boost to the growth of long-term freight capacity. At the same time, it can effectively increase the enterprise surplus and logistics jobs.

However, it is inevitable that the increase of urban logistics activities and corporate freight vehicles has significantly increased the level of environmental pollution and urban congestion. The aggravation of urban congestion will lead to the decline of the annual capacity of enterprise freight vehicles. In order to ensure the sustainable development of uran logistics, not only the service capability should be improved, but the number of freight vehicles and logitics activities also should be controlled in a reasonable range.

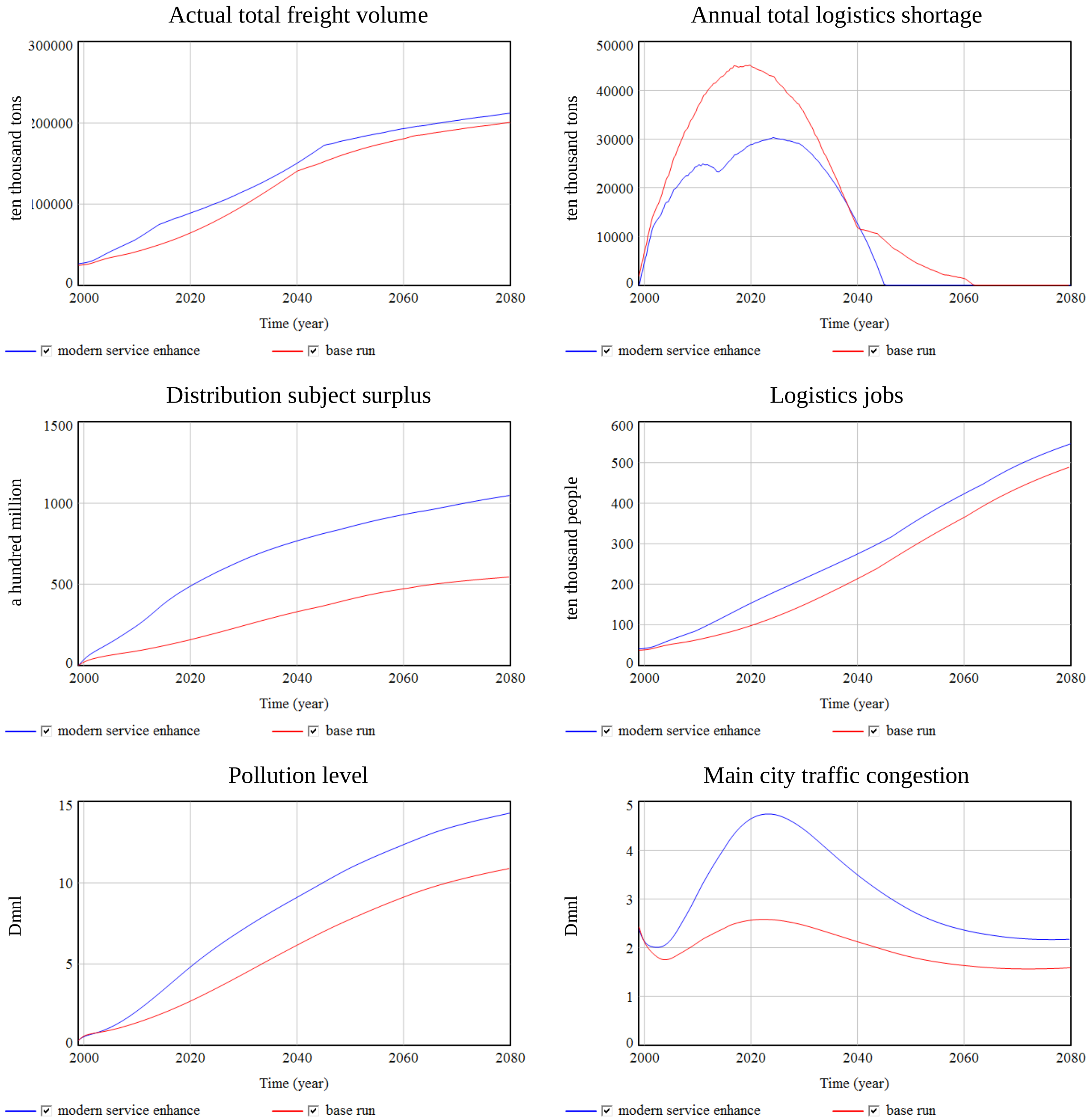


Figure 29 The simulation results of modern service capability policy

Attracting logistics talents

In order to test the **impact of attraction policies of logistics talents** on the development of urban logistics industry, a policy lever that can control multiple logistics labor related factors is constructed. The factors controlled in the model include the **wage level factor** and the **proportion of the permanent population engaged in logistics industry**. The KPI under different situation of talent attraction policies are simulated and the results are shown in Figure 30. It can be seen that the talent attraction policy has not increased the actual freight volume either in the short or long term. Only in the short term, it can alleviate the logistics shortage faintly. However, in the long run, it significantly slows down the reduction of logistics shortage. Based on the analysis of system causality, this situation is partly caused by the fact that the increase of labor cost in logistics enterprises has a great impact on the development of enterprises. The profit margins of logistics industry is low. Raising the wage level of logistics practitioners, on the one hand, attracts more logistics talents, but at the same time, the operating pressure of logistics enterprises increases. The corporate surplus will be significantly reduced, and the investment in freight vehicles and technical equipment will be correspondingly reduced. Generally speaking, simply increasing the salary level of logistics industry cannot promote the development of Chongqing logistics industry.

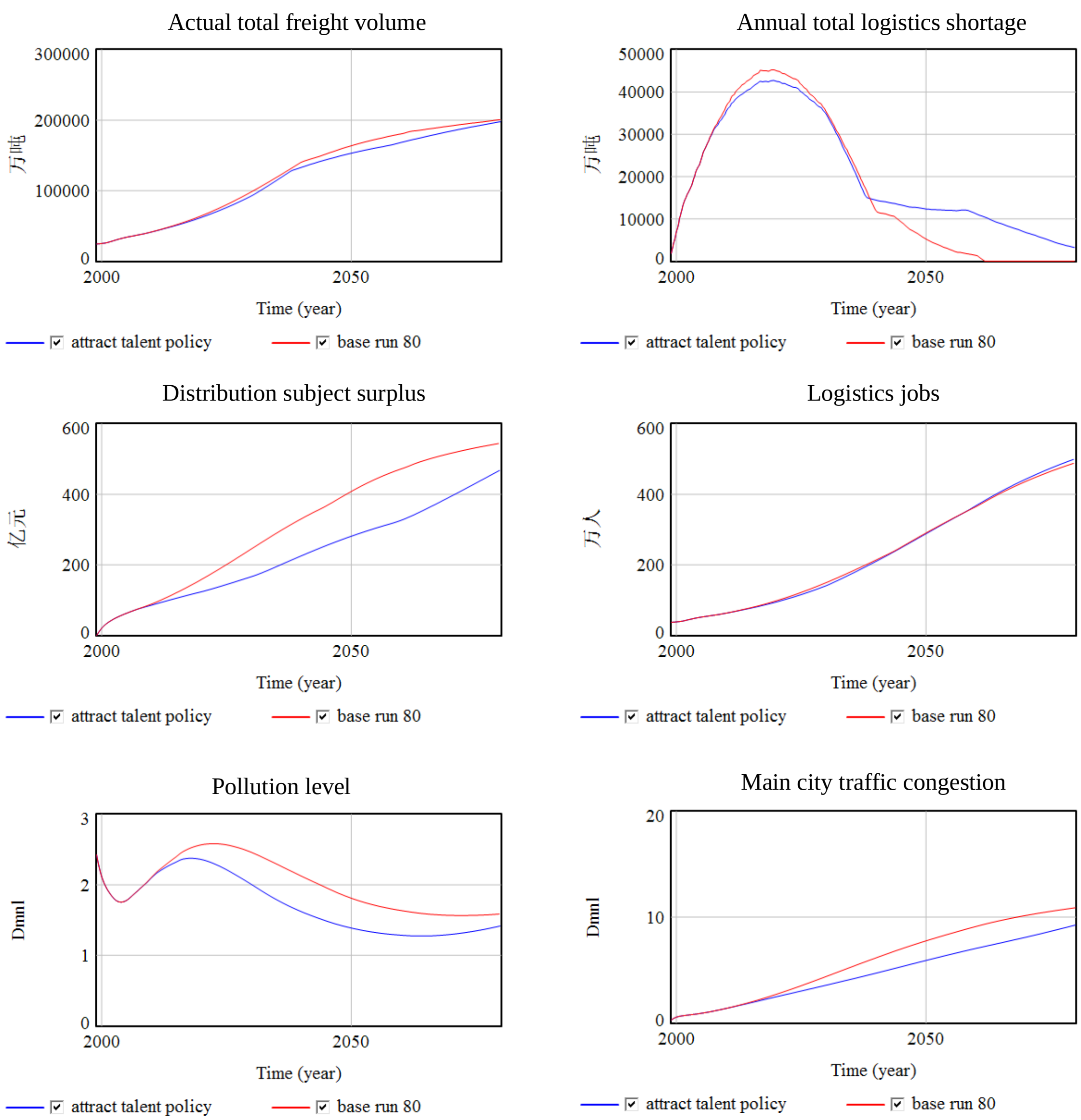


Figure 30 The simulation results of talent attracting policy

Alleviating traffic congestion

There are many types of policies that can alleviate traffic congestion. For example, increasing the density of urban roads, restrict the transit time of freight vehicles, and restrict the traffic of urban vehicles on odd and even numbers, etc. According to the analysis of congestion in the main urban area of Chongqing in section 4.4.4, since Chongqing is a mountain city, the geographical characteristics make it **difficult to further increase the density and capacity of roads**. Excessive vehicle traffic restrictions would **not only ease traffic congestion**, **but also increase difficulty of urban freight**. Therefore, the measure of **reducing the distance of freight** is adopted in this paper. It is simulated to test the impact of traffic congestion alleviation policy. The simulation results are shown in Figure 31.

Most of the **logistics parks** in Chongqing are distributed in the **outer ring** of the main urban area from the initial planning. They are mainly around the second ring line, and the layout is **as close as possible to the transportation hub**. However, the **main wholesale markets** in Chongqing are located in the urban area. They are **close to the residential area and far from the logistics center**. Therefore, in view of the special situation in Chongqing, in order to **reduce the transportation distance of goods** and improve logistics efficiency, **the strategy of moving out of the wholesale market** should be adopted.

In the model, the change of the wholesale market position can be simulated by changing the "**distance between logistics center and distribution terminal**". The initial value of the model is set to 30km. The wholesale market migrating strategy is simulated as the reduction in this constant in the model. It should be noted that the wholesale market will increase the distance between the distribution terminal and the residential area, so that the distance traveled by residents will increase, which will inevitably **increase the passenger traffic volume** of the city, which will **affect the traffic load intensity** of the city. This process is simulated by the "**Distribution Terminal and Resident Distance**" variable in the traffic subsystem of this model. The increase in the "distance between the distribution terminal and the residents" will increase the "per capita travel distance", thereby increasing the "passenger volume of passenger vehicles".

In this paper, the distance between the logistics center and the distribution terminal is changed from 30km to 5km, simulating the migration of wholesale market to the vicinity of the logistics center. The simulation results are shown in the Figure 31.

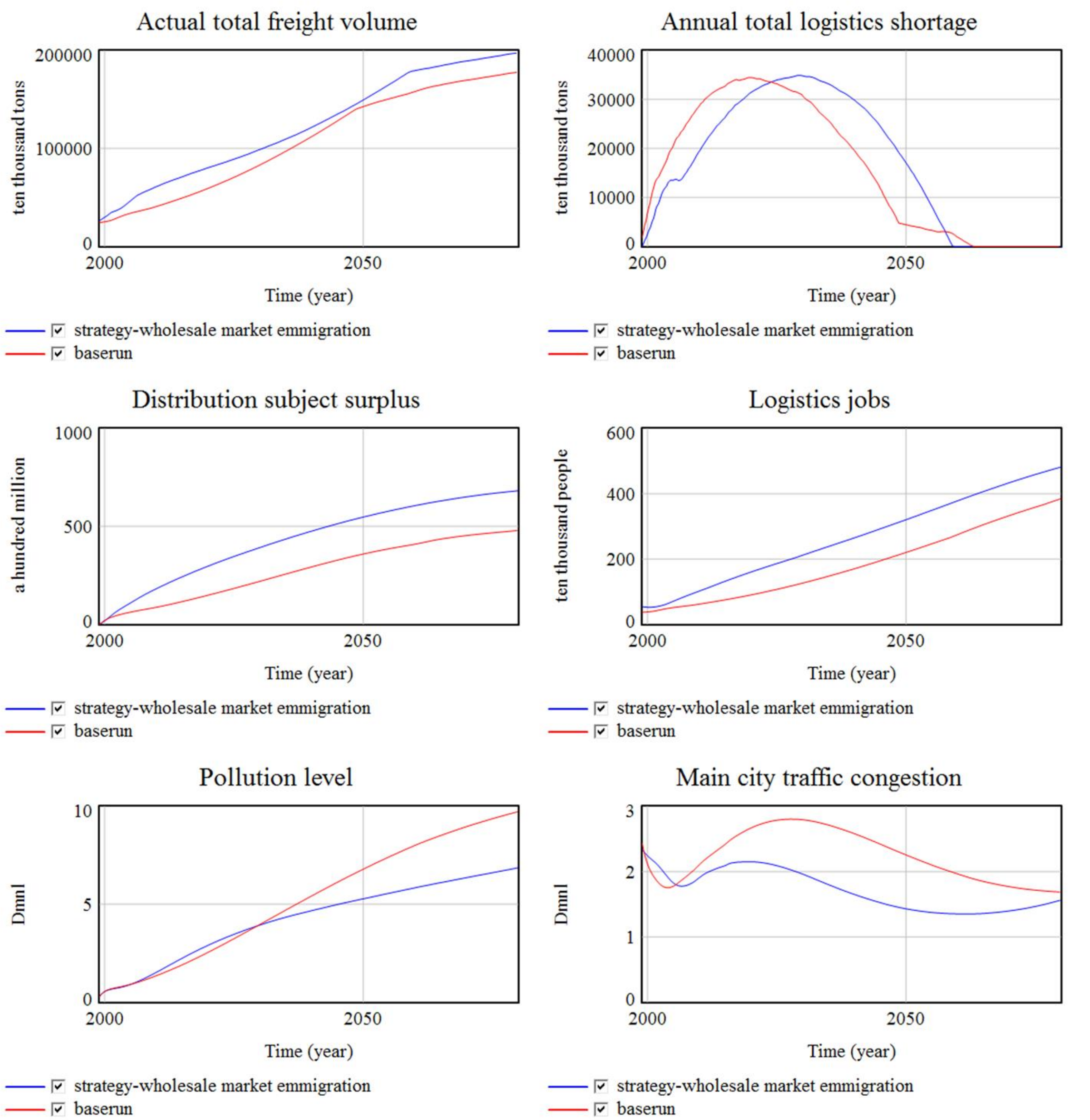


Figure 31 Simulation results of the wholesale market emmigration policy

It can be seen from Figure 31 that the wholesale market can increase the actual total freight volume of Chongqing. It is effective in short-to-medium term in reducing the total shortage of logistics. And in the medium and long term, it can significantly improve the traffic congestion in the main city. The improvement of the urban environment in the short term is limited, but in the long run, it will improve the urban environment. But it should also be seen that although this policy would reduce the logistics shortage at the beginning, after about 2025, the total logistics shortage would decline slowly, and the shortage is higher than base case.

5.5 Implementation of policies

Chongqing has a typical export-oriented economy. The volume of trade in the early years is dominated by foreign imports and exports. But since the international financial crisis, the global economy has been stuck in a pattern of long-term stagnation. In addition, the global economic and trade friction, represented by those between China and the United States, have intensified. It makes foreign trade demand generally weak and erratic. It is becoming more and more difficult to rely on external demand to drive the growth of Chongqing's economy and trade. In the meanwhile, China has become the second largest economy in the world. Therefore, Chongqing should follow the pattern of double-cycle development of national economy. **One the one hand**, it should make use of China's strategic policy of expanding opening-up in an all-round way to strengthen trade partnerships with countries and regions along the "One Belt and One Road", **promoting the diversification of trade partners**. The actual trade cooperation projects should be used to promote the total volume of Chongqing import and export trade growth. **On the other hand**, the development of a **complete system of domestic demand** should be accelerated, following the new development pattern to promote the external demand by domestic demand. In order to keep Chongqing's trade volume growing steadily and continuously, the domestic and internaltional double cycles should be constructed and mutually promoted, while China's major circulation plays the leading role.

As the key logistics hub city of "One belt and one road" and Yangtze River Economic Belt, Chongqing has the important responsibility of opening up the international trade channel and the international and domestic economic double circulation. On the basis of the overall improvement of logistics infrastructure in Chongqing, **the efficiency, professionalism and reasonable allocation of resources of enterprises are also of great importance**. In order to solve the problems of dispersed, small scale and low degree of modernization of logistics enterprises in Chongqing, it is necessary to **cultivate a group of leading third party and fourth party logistics enterprises** with strong competitiveness and high popularity, as well as **small and medium-sized logistics enterprises with sufficient vitality and specialized business**. It is also necessary to improve logistics enterprises' modern logistics technology, management ability and comprehensive service ability, and promote specialization, standardization, informatization, internationalization and branding of logistics enterprises. The number of 5A level logistics enterprises with large-scale in the city should be increased.

With the comprehensive construction and vigorous development of Chongqing International Logistics Channel and Yangtze River Economic Belt. Logistics human resources, especially the demand for **high-quality technical and skilled logistics personnel** can be expected to grow gradually. Facing the huge demand and supply gap of logistics talents, Chongqing should take various measures, including **optimizing the training mode of logistics talents, improving the social qualification certification system and enhancing the attractiveness of high-end urban talents**. So as to provide a multi-level, international, modern logistics personnel guarantee to various strategic plannings such as "One Belt One Road", China-Singapore project cooperation and free trade zone, etc.

5.6 Chapter summary

According to the research purpose, this chapter first set the **system hypothesis** and **system boundary**, removes the content unrelated to the research goal, and sets the **KPI** of the model according to the logistics evaluation standard in Chapter 3 and the crux of Chongqing logistics development in Chapter 4. The **causal feedback relationship** of each component of the logistics system in Chongqing was analyzed and **CLD** was constructed. According to the corresponding analysis in the Chapter 4, *logistics-supply & demand subsystem*, *logistics-economy subsystem*, *logistics-Social subsystem*, *logistics-Environment subsystem* and *logistics-Transportation subsystem* are constructed to simulate the **dynamic relationship between the internal elements of the logistics and the external environment**. After the construction of the model, the **validity** of the model is analyzed by direct structure test and structure-oriented behavior tests. The base case test results show that the model can effectively simulate the logistics situation in Chongqing. The results of the boundary adequacy test show that the model running time is sufficient to show all the key changes. Through the extreme condition behaviour test and sensitivity analysis, it is known that the model is in equilibrium. Through the **simulation** of SD model, **four policeis for Chongqing are deeply analyzed**, which are promoting trade demand, improving modern service capability, attracting logistics talents and alleviating traffic congestion.

Conclusion

On the basis of systematic review of relevant research of urban logistics, the **case analysis**, **systematical approach** and **SD modeling and simulation method** are conducted to analyze the architecture of logistics system and the effective strategies. The **framework of urban logistics system** are analyzed and summarized. In view of the sustainable development goal of urban logistics system, the **evaluation standard** of logistics system development is put forward. Based on the research and analysis of the current **situation & crux of Chongqing's logistics**, real data were substituded in to SD model. The **influence of different policies** on the development of urban logistics is deeply analyzed through the simulation results. The main conclusions of this paper are as follows.

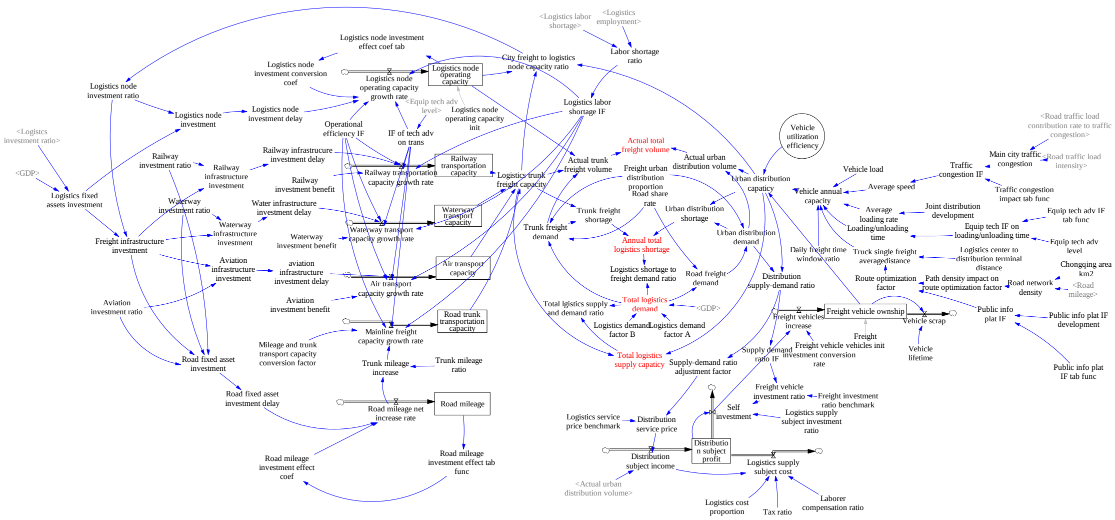
1）The **architecture of urban logistics system** includes material basic elements, participating subject elements, environmental elements. Material basic elements includes includes logistics infrastructure and information systems. Participating subject elements can be divided in to demand subject, supply subject, local government department and city resident. Environmental element includes economic, social, traffic and ecological factors. Logistics-related public policies can improve the dynamic equilibrium state of the logistics system by acting on the internal members of the logistics system. It is an essential measure to regulate the sustainable development of urban logistics. The development goal of urban logistics should be the optimization of public interests. The **evaluation index** of urban logistics development is put forward, which are meeting the demand of economic development, logistics corporate profit, and urban competitiveness promotion.

2）Through the analysis of the specific situation of Chongqing, the **main difficulties encountered** in the development of Chongqing logistics industry are as follows: First is the shrinking of global trade volume and logistics demand. Second is the scattered corporations and lack of modern technology. Third is the shortage of seniro logistics talent. Fourth is the severe congestion in the main city area.

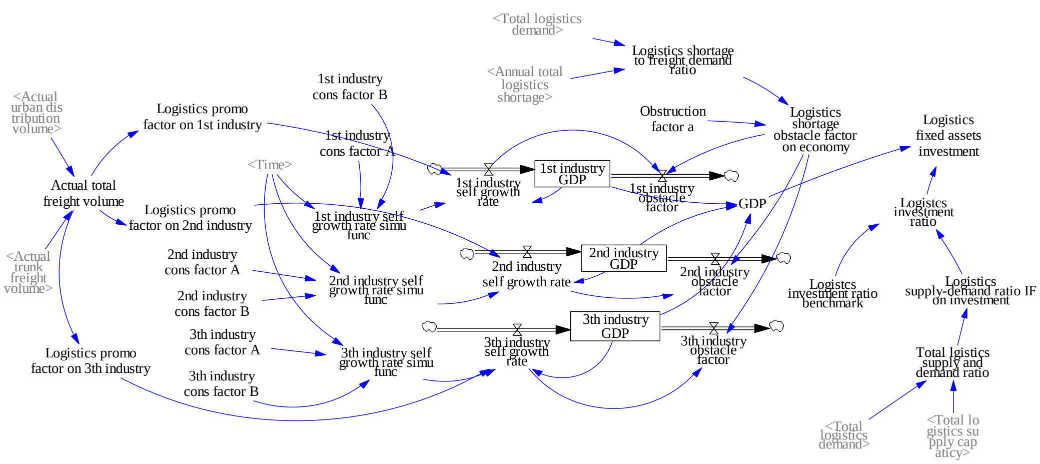
3）Based on the architecture of urban logistics system and the real data of Chongqing, the **SD model** of Chongqing logistics system is constructed in this paper. Through the **simulation analysis of several policies**, the following conclusions are drawn: Promoting trade demand and improving the service level of logistics enterprises have obvious effect on the evaluation index of Chongqing logistics development. However, the increase of logistics activities would also increase the congestion and pollution level of the city. Simply increasing the salary level of logistics talents cannot effectively improve the development of urban logistics, but will increase the operation cost of enterprises and reduce the logistics service ability. According to the special mountainous terrain of Chongqing, the relocation of the original wholesale market can effectively alleviate the urban traffic congestion, which will further enhance the logistics and freight capacity and the development level of urban logistics.

Appendix

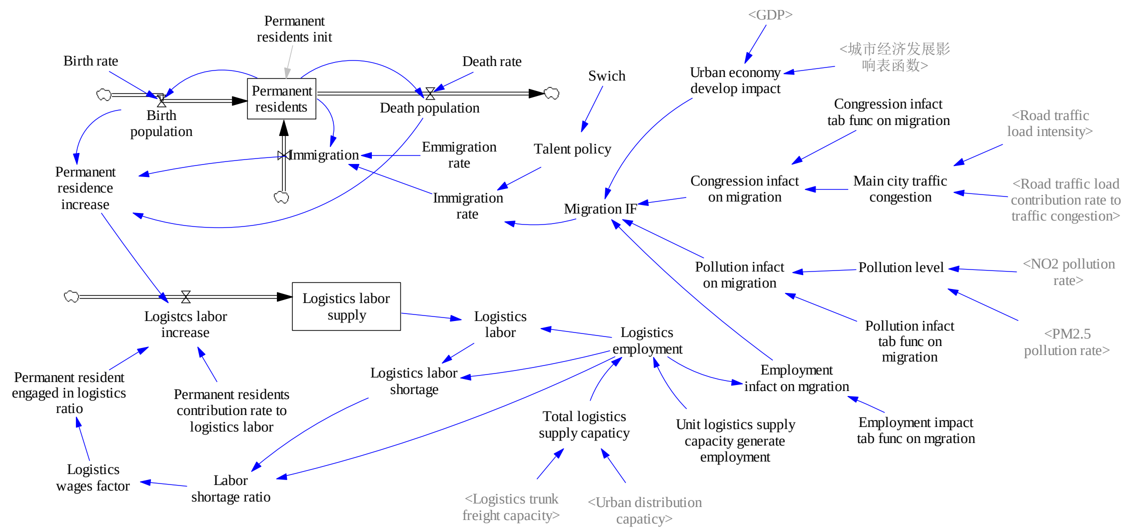
Appendix1 Stock Flow Diagram of SD model



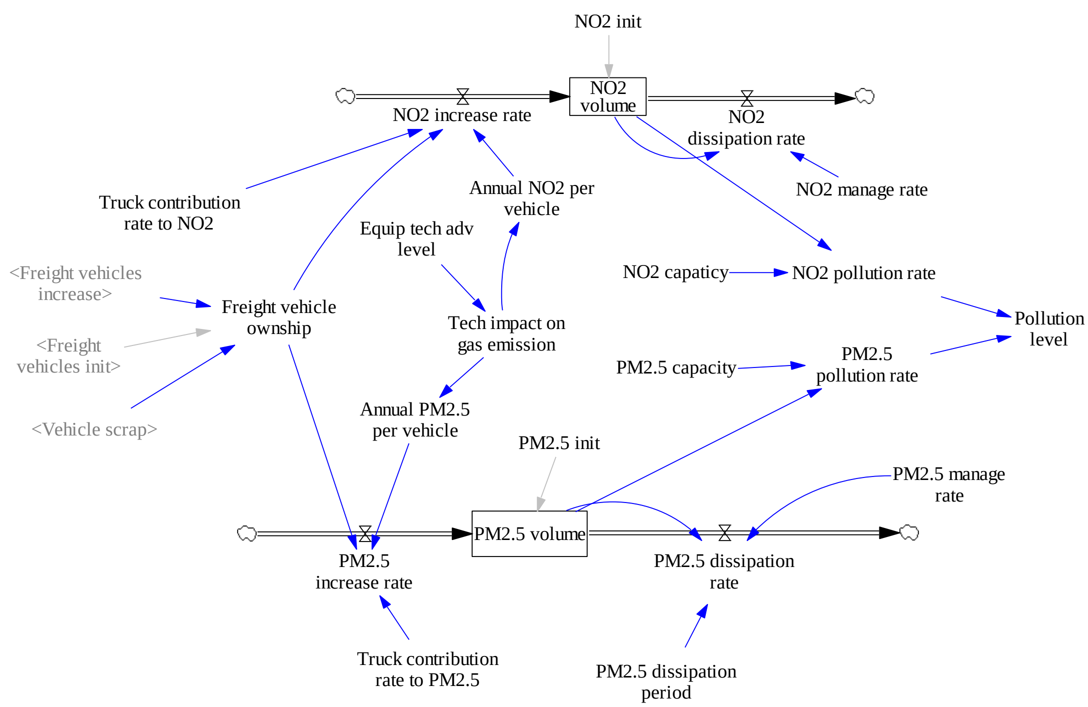
Appendix Figure 1 Stock Flow Diagram of Urban logistics supply&demand subsystem



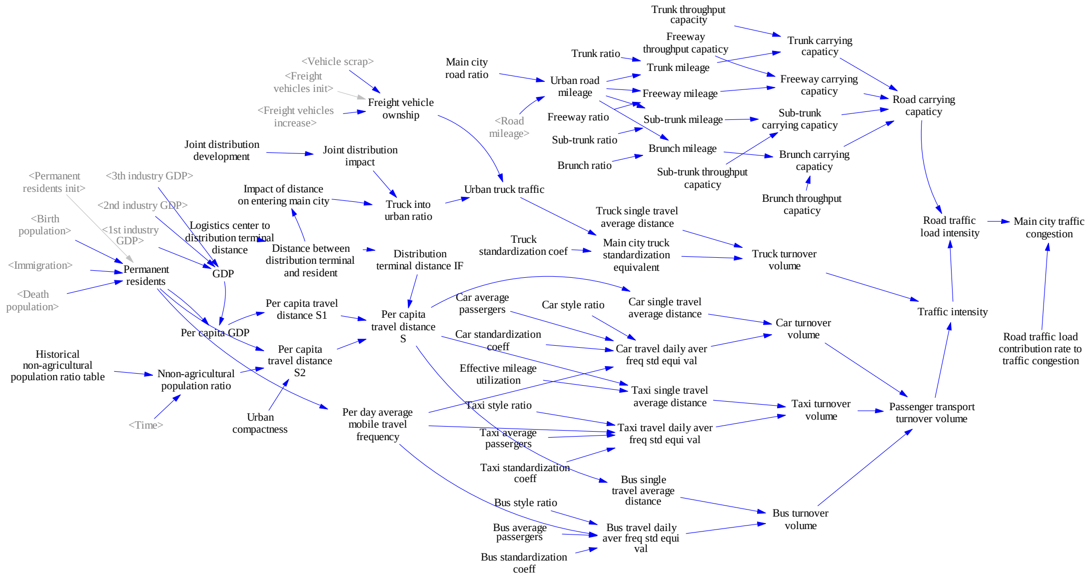
Appendix Figure 2 Stock Flow Diagram of Urban logistics-economy subsystem



Appendix Figure 3 Stock flow diagram of Urban logistics-social subsystem



Appendix Figure 4 Stock flow diagram of Urban logistics-enviornment subsystem



Appendix Figure 5 Stock flow diagram of Urban logistics-transportation subsystem

Appendix2 Estimate and Assumption of main parameter of SD model

The selection and determination of parameters in this model are based on data collection, literature research and mathematical calculation. The sources of data include Chongqing Statistical Yearbook of the past years, annual report of traffic development of Chongqing, annual report of traffic operation analysis of Chongqing main city, etc.

1. Urban logistics supply&demand subsystem

(1) Urban logistics total supply capacity

The urban logistics supply capacity is mainly reflected in three parts, which are urban cargo transportation, logistics warehousing and transshipment, and urban internal distribution. Since freight volume is used as the quantitative input value of logistics demand and supply capacity in this paper, only the distribution capacity (intra-city branch freight volume) and the trunk transport capacity (mainline freight volume) are summed as the total logistics supply capacity.

Actual total freight volume=Actual urban distribution volume+Actual trunk freight volume

(2) Urban distribution capacity

Urban logistics distribution refers to logistics activities with frequent and small batches and multiple users. It is based on the urban internal road network, using small and medium-sized freight vehicles. Urban logistics distribution activities exist in the living environment of the city and have an interactive relationship with the human settlement environment. Therefore, the city's distribution capacity depends not only on the road mileage of urban roads and the number of urban trucks, but also the impact of urban traffic congestion.

Urban distribution capacity = Freight vehicle ownship*Vehicle utilization efficiency*Vehicle annual capacity

Freight vehicle ownership = Integ (Freight vehicles increase-Vehicle scrap, initial value of freight vehicles)

Freight vehicles increase = Self investment*Freight vehicle investment conversion rate

Self-investment = Distribution subject surplus*Freight vehicle investment ratio*Logistics supply subject investment ratio

Distribution subject surplus = Integ(Distribution subject income-Logistics supply subject cost-Self investment, 0)

Distribution subject income = Actual urban distribution volume*Distribution service price

Actual urban distribution volume = MIN(Urban distribution capaticy,Urban distribution demand)

Distribution service price = Logistics service price benchmark*Supply demand ratio adjustment factor

Logistics supply subject cost = Distribution subject income*(Logistics cost proportion+Tax ratio+Laborer compensation ratio)

Vehicle annual capacity = Vehicle load/10000*Average loading rate*(24*Daily freight time window ratio/((2*Truck single freight averagedistance/Average speed)+"Loading/unloading time"))*365

Among them, the average speed is affected by urban traffic congestion, assuming a base speed of 60km/h.

Average speed = 60*Traffic congestion IF

The loading and unloading time is affected by the degree of equipment technology development, assuming the benchmark loading and unloading time is 1h.

Loading /unloading time= 1*"Equip tech IF on loading/unloading time"

Single transport average distance = Logistics center to distribution terminal distance*Route optimization factor

Route Optimization Factor = Public info plat IF*Path density impact on route optimization factor

The influence factor of road network density on path optimization increases with the increase of road network density, and the rate of change is controlled by the table function.

Road network density = Road mileage/Chongqing area km2

(3) Logistics node operation capability

According to the analysis in Chapter 3 and Chapter 4, the logistics nodes include urban freight hubs, logistics parks, logistics centers, distribution centers, etc. Their operational capabilities are mainly reflected in warehousing, loading and unloading and handling capabilities. The storage capacity depends on the floor area of the logistics node, the type of warehouse (planar library, stereo library, multi-layer library), cargo turnover time, etc. The loading/unloading capacity depends on the number of loading units, the utilization rate, and the overall productivity. For different logistics nodes, the loading unit can be different types of machine or loader with different productivity. The handling capacity mainly depends on the operation efficiency of the handling equipment in logistics nodes. Generally, the handling equipment in the logistics node is mainly the conveyor belt and the shuttle bus, and manual freight handling is also existing in some nodes. In order to simplify the model, the warehousing, loading and unloading and handling capabilities of the nodes are summarized and simplified to the node operation capability. The whole society's investment in logistics node warehouse area, loading and unloading equipment, handling equipment and other facilities can be converted into the increase of logistics node operation capacity through the logistics node investment conversion coefficient. In addition to the increase in facilities, the upgrading of equipment and technology, the efficiency of business operations, and the shortage of logistics labor will also affect the growth rate of logistics node operations.

Logistics node operation capability =INTEG(Logistics node operating capacity growth rate, Logistics node operating capacity init)

Logistics node operation capacity growth rate = Logistics node investment delay*Logistics node investment conversion coef*IF of tech adv on trans*Operational efficiency IF*Logistics labor shortage IF

(4) Logistics trunk transportation capacity

In this article, logistics trunk transportation capacity only includes railway, waterway, air transport, and road transport, which are respectively integral of each growth rate. Initial value is set as freight data in 1999. Corresponding fixed asset investments can increase transport infrastructure and work efficiency, thereby increasing transport capacity.

Railway transportation capacity= Integ (Railway transportation capacity growth rate, 2790)

Railway transportation capacity growth rate = Railway infrastrucure investment delay*Railway investment benefit*IF of tech adv on trans*Operational efficiency IF*Logistics labor shortage IF

Water transport capacity = Integ (Waterway transport capacity growth rate, 1395)

Waterway transport capacity growth rate = Water infrastructure investment delay*Waterway investment benefit*IF of tech adv on trans*Operational efficiency IF*Logistics labor shortage IF

Air transport capacity = Integ (Air transport capacity growth rate, 3)

Air transport capacity growth rate = aviation infrastructure investment delay*Aviation investment benefit*IF of tech adv on trans*Operational efficiency IF*Logistics labor shortage IF

Highway trunk transportation capacity = Integ (Mainline freight capacity growth rate, 8880.8)

Mainline freight capacity growth rate = Trunk mileage increase*Mileage and trunk transport capacity conversion factor*Logistics labor shortage IF*Operational efficiency IF*IF of tech adv on trans

Road mileage= integ (Road mileage net increase rate, 71465.9)

Road mileage net increase rate = Road mileage investment effect coef*Road fixed asset investment delay

(5) Total logistics demand

Urban logistics demand has a strong correlation with urban economic development. According to the relationship between urban output value and freight volume, a regression model is established and the regression parameters of the model are calculated by least squares estimation in this paper. The regression equation is as follows.

Total logistics demand = 36088*Ln(GDP)-241252

(6) Total annual shortage of logistics

Annual total logistics shortage = Urban distribution shortage+Trunk freight shortage

Urban distribution shortage = MAX(0,Urban distribution demand-Urban distribution capaticy)

Urban distribution demand = Road freight demand*Freight urban distribution proportion

Trunk freight shortage = MAX(0,Trunk freight demand-Logistics trunk freight capacity)

Trunk freight demand= Total logistics demand*(1-Road share rate)+Total logistics demand*Road share rate*(1-Freight urban distribution proportion)

2. Urban logistics-economic subsystem

In order to better simulate the actual situation, the growth rate of output value of various industries in Chongqing from 1999 to 2016 are taken as the benchmark value. On the basis of it, comprehensive consideration of the logistics shortage, environmental pollution, traffic congestion and economic hindrance are taken, and the growth rate equation of each industry's output value are obtained.

Primary industry GDP = Integ(Primary industry self growth rate- Primary industry obstacle factor, 286.16)

Primary industry self growth rate = Primary industry GDP*Primary industry self growth rate simu func*Logistics promo factor on 1st industry

Primary industry obstacle factor = Primary industry self growth rate*Logistics shortage obstacle factor on economy

Primary industry self growth rate simu func = RANDOM NORMAL(0, (Primary industry cons factor A*EXP(-(1/25)*(Time-1999))+Primary industry cons factor B), 0.01, 1, 1234)

3. Urban logistics-social subsystem

The dynamic balance between the number of jobs and the labor supply in the urban logistics industry determines the number of employees in the urban logistics industry. When the labor supply cannot meet the demand for logistics jobs, there is a labor shortage in the logistics industry. The labor supply capacity of the logistics industry depends on the city's permanent population and migrant workers. The number of permanent residents varies dynamically with changes in birth, death and population migration. This paper assumes that in a certain period of time, the urban birth rate and mortality rate remain relatively constant, and the population migration rate changes with the impact of urban economic development, the number of jobs, environmental pollution levels, and traffic congestion. Several important variable equations in the social subsystem are as follows.

Logistics labor supply = Integ(Logistcs labor increase, 69.47)

Logistics labor= MIN(Logistics labor supply,Logistics jobs)

Logistics jobs= Unit logistics supply capacity generate employment*Total logistics supply capaticy

Logistics labor shortage = MAX(0, Logistics jobs-Logistics labor)

Immigration = Permanent residents*(Immigration rate-Emmigration rate)

Permanent residents = Integ(Immigration+Birth population-Death population, Permanent residents init)

Permanent residence increase= Birth population-Death population+Immigration

Immigration rate= 0.03*Migration IF*Talent policy

Migration IF = (1-Congression infact on migration)*(1+Employment infact on mgration)*(1-Pollution infact on migration)*(1+Urban economy develop impact)

Urban economy develop impact = Urban economic development impact table func(GDP)

Congression infact on migration = Congression infact tab func on migration(Main city traffic congestion)

Pollution infact on migration = Pollution infact tab func on migration(Pollution level)

Employment infact on migration = Employment impact tab func on mgration(Logistics jobs)

4. Urban logistics-enviornment subsystem

Only two types of vehicle exhaust emissions, which have the greatest impact on the environment, are focused on in this paper, namely NO2 and inhalable particulate matter (IP). The increase rate of NO2 and IP can be calculated from the number of trucks, the average truck emissions, and the contribution rate of trucks. The rate of dissipation depends on the treatment of pollutants in the city. If there is no external control measures, the pollutants have a basic dissipation rate and dissipation time.

NO2 pollution rate (NO2PP) and inhalable particulate matter pollution rate (IPPP) can be calculated by dividing the corresponding atmospheric content and capacity. The environmental pollution level (EPL) is calculated by weighted average of NO2PP and IPPP. It is simplified to 1:1 in this paper.

$$\mathrm{NO2PP=NO2C/NO2CA}$$
$$\mathrm{IPPP= IPC/IPCA}$$
$$\mathrm{EPL}=\frac{1}{2}\mathrm{NO2PP}+\frac{1}{2}\mathrm{IPPP}$$

5. Urban logistics-transportation subsystem

(1) Urban transportation congestion

The definition of traffic congestion in this paper is the external performance of traffic demand exceeding the traffic supply. It refers to the fact that the number of vehicles that want to pass the road exceeds the road capacity in a certain period of time, forming a queuing phenomenon on the road. Traffic congestion on urban roads is measured by road traffic load intensity (TLI). Due to the unique location characteristics of Chongqing City, another part of Chongqing road network traffic congestion comes from the congestion of the cross-river bridge and the mountain tunnel. The proportion of urban road traffic congestion to the entire road network congestion is represented by the contribution rate of road traffic load to traffic congestion in this paper.

$$UTC= TLI/CRTLTC$$

Among them, road traffic load intensity (TLI) is the ratio of traffic intensity (TI) to road traffic carrying capacity (TCC), which is positively correlated with road traffic congestion. The larger the indicator, the more serious traffic congestion. Road traffic intensity is defined as the amount of vehicle turnover (vehicles per day) that occurs within a certain spatial range. Truck vehicle turnover (FVT), car vehicle turnover (CarT), taxi vehicle turnover (TaxiT), bus vehicle turnover (BusT) are included in this paper. The vehicle turnover is the product of the average daily travel frequency (pcu times/day) of the vehicle and the average single travel distance (km/time).

$$TLI= TI/TCC$$

$$TI= FVT+ CarT+ TaxiT+ BusT$$

$$CarT= CarDTFSE*CarASTD$$

$$TaxiT=TaxiDTFSE*TaxiASTD$$

$$BusT =BusDTFSE*BusASTD$$

The road traffic carrying capacity is defined as the daily converted vehicle turnover (pcu km/day) that can be assumed by a certain scale road network at an average speed of 60km/h. Different levels of roads have different levels of traffic capacity.

$$TCC=\sum \text{lane mileage of roads at all levels} \times \text{road capacity at all levels}$$

According to the actual situation of the road network in Chongqing, urban roads can be divided into main roads, express roads, secondary trunk roads and branch roads. The corresponding road traffic carrying capacity is as follow.

$$TCC=MajorATCC+ExpresswayTCC+MinorATCC+CollectorSTCC$$

$$MajorATCC =MajorACapacity*MajorAMileage$$

$$ExpresswayTCC= ExpressCapacity*ExpressMileage$$

$$MinorATCC =MinorACapacity*MinorAMileage$$

$$CollectorSTCC =CollectorSCapacity*CollectorSMileage$$

Through the combination of urban road traffic planning, route design specifications in Chongqing and the experience of people in the industry, the road capacity of each level is set as shown in the table. The mountainous area of Chongqing's main urban area is 2,250 square kilometers, accounting for 41.09%, the hilly area is 2,739 square kilometers, accounting for 50.03%, and the flat dam and platform area is 368 square kilometers, accounting for only 6.7%. Therefore, the proportion of heavy hills is calculated by more than 70%.

Appendix Table 1 Road capacity setting at all levels

Road grade	Experience value (pcu/day)	Specification value (pcu/day)		Setting value (pcu/day)
		rolling terrain	Mountainous area	
express way	24000-28800	>30000	<20000	24000
arterial road	21600	>20000	<10000	13000

sub-arterial	14400	>10000	<5000	8000
branching	7200-9600	>5000	<2000	3000

(2) Average travel distance

Citing Mao Haijun's (2005) research conclusions on the impact of urban size, shape and per capita GDP on per capita travel distance and frequency in his doctoral thesis “Research on the Characteristics of Chinese Residents' Travel”.

The relationship between per capita travel distance and per capita GDP:

$$\text{Extra large and megacities: } S1=0.39066\ln(G)+0.34706$$

Where S1 is the per capita travel distance (km) and G is the per capita GDP (Yuan/person).

The relationship between per capita travel distance and city size and urban form is as follow.

$$S2=0.23687+0.99743\ln(P)-4.10184*C$$

In the formula, S2 is the per capita travel distance (km), P is the urban non-agricultural population (10,000 people), and C is the urban compactness.

According to the analysis in Chapter 4, Chongqing is a multi-center evenly distributed group. According to the doctoral thesis of Mao Haijun (2005), the urban compactness of Chongqing is 0.201. The correlation coefficient between GDP per capita and travel distance is 0.3740. The correlation coefficient between city size and shape and travel distance is 0.82339. The two correlation coefficients are normalized to obtain the comprehensive influence relationship between per capita GDP, city size and urban form on the per capita travel distance.

$$S=0.31235*S1+0.68765*S2$$

Where S is the per capita travel distance (km) under the influence of the comprehensive factors, which is the value represented in the model.

(3) Daily travel frequency for different travel modes

According to the binary linear regression of Chongqing Daily Average Motorized Travel Frequency (ADMTF) from 1999 to 2016, Chongqing Motor Vehicle Ownership (MVO) and Resident Population (RP), the daily average motorized travel frequency equation is as below.

$$ADMTF= 6.766MVO-1.1476RP+3481.77$$

Residents' motorized travel includes many modes of travel such as private cars and public transportation. In order to study urban traffic congestion, only cars, taxis and buses are considered, which have a greater impact on urban road traffic. The normalized equivalent number of daily average travel frequencies for different travel modes can be calculated.

$$CarDTFSE=10000*ADMTF*CarR/(ANPCCar*CarSC)$$
$$TaxiDTFSE=10000*ADMTF*TaxiR/(ANPCTaxi*TaxiSC)$$
$$BusDTFSE=10000*ADMTF*BusR/(ANPCBus* BusSC)$$

According to the "Chongqing City Road Traffic Planning and Route Design Specification", and the actual situation of Chongqing, the standardization coefficient of the vehicle is set as shown in the table.

Appendix Table2 Standardized coefficient setting for vehicles

Vehicle type	Vehicle overall size	Standardized Coefficients
Car	5.5	1
bus	12	2.1
taxi	5.5	1
Medium truck	9	1.6

(4) Single travel distance for different modes of travel

Considering that the flexibility of cars, taxis, and buses is lower than that of residents walking and motorcycles, the single travel distances of these three modes are set longer than the single travel distance per person. In addition, since the taxi has more no-load driving conditions, the average single travel distance of the taxi is calculated by the combination of the per-person travel distance and the effective mileage utilization rate of the taxi. According to the traffic report of Chongqing from 11 to 16 years, the average utilization rate of effective mileage of taxis was 70.683% (source: Chongqing Municipal Transportation Commission, Chongqing Municipal Road Transportation Administration).

CarASTD=ATDistancePC*(1+0.5)

TaxiASTD=ATDistancePC*(1+0.6)/URVDTaxi

BusASTD=ATDistancePC*(1+0.8)

Reference

Ambrosini, C. and Routhier, J.L. (2004), “Objectives, methods and results of surveys carried out in the field of urban freight transport: an international comparison”, Transport Reviews, Vol. 24 No. 1, pp. 57-77.

Anderson, S., Allen, J., & Browne, M. (2005). Urban logistics—how can it meet policy makers’ sustainability objectives?. Journal of transport geography, 13(1), 71-81.

Aoyama, Y., & Ratick, S. J. (2007). Trust, transactions, and information technologies in the US logistics industry.Economic Geography, 83(2), 159-180.

Ballantyne, E.E.F., Lindholm, M. and Whiteing, A. (2013), “A comparative study of urban freight transport planning: addressing stakeholder needs”, Journal of Transport Geography, Vol. 32, October, pp. 93-101.

Bjerkan, K.Y., Sund, A.B. and Nordtømme, M.E. (2014), “Stakeholder responses to measures green and efficient urban freight”, Research in Transportation Business & Management, Managing Freight in Urban Areas, Vol. 11, July, pp. 32-42.

Bowersox, D. J., Closs, D. J., & Cooper, M. B. (2002). *Supply chain logistics management* (Vol. 2). New York, NY: McGraw-Hill.

CFLP, (2002). Logistics industry is a new growth point for China's economy. China Logistics and Purchasing, (8): 8-11.

Debao, D., &Tijun, F., &Qi, A. (2018). Research on Comprehensive Evaluation and Coordinated Development of Logistics in Western Regions. China Soft Science, (1), 90-99.

Dolati Neghabadi, P., Evrard Samuel, K., & Espinouse, M. L. (2018). Systematic literature review on city logistics: overview, classification and analysis. International Journal of Production Research, 1-23. SLR2018

Dong, B. (2011). Status and prospects of intelligent transportation development. China Security Protection Certification, 2011(1): 61-64.

Gammelgaard, B. (2015), “The emergence of city logistics: the case of Copenhagen’s citylogistik-kbh”, International Journal of Physical Distribution & Logistics Management, Vol. 45 No. 4, pp. 333-351.

Gatta, V. and Marcucci, E. (2014), “Urban freight transport and policy changes: improving decision makers’ awareness via an agent-specific approach”, Transport Policy, Vol. 36 No. C, pp. 248-252.

Gayialis, S. P., Konstantakopoulos, G. D., & Tatsiopoulos, I. P. (2019). Vehicle Routing Problem for Urban Freight Transportation: A Review of the Recent Literature. InOperational Research in the Digital Era–ICT Challenges (pp. 89-104). Springer, Cham.

Goh, M., & Ling, C. (2003). Logistics development in China.International Journal of Physical Distribution & Logistics Management, 33(10), 886-917.

Hensher, D.A. and Puckett, S. (2005), “Refocusing the modelling of freight distribution: development of an economic-based framework to evaluate supply chain behaviour in response to congestion charging”, Transportation, Vol. 32 No. 6, pp. 573-602.

Hensher, D. A., & Puckett, S. (2004). Freight Distribution in Urban Areas: The role of supply chain alliances in addressing the challenge of traffic congestion for city logistics.

Hesse, M. (2016). The city as a terminal: The urban context of logistics and freight transport. Routledge.

Holguín-Veras, J. (2008), “Necessary conditions for off-hour deliveries and the effectiveness of urban freight road pricing and alternative financial policies in competitive markets”, Transportation Research Part A: Policy and Practice, Vol. 42 No. 2, pp. 392-413.

Hong, F., 2006. Research on urban logistics. Higher Education Press.

Hong, X. (2013). Analysis and Optimization Research on Beijing’s Urban Logistics System Based on System Dynamics (Master’s dissertation, Beijing: Beijing Jiaotong University)

Huiming, Z. (2015). Organization of Local Logistics Networks in Urban China Under Globalization.Science Press.

Huiming, Z., Jianhui, Y., & Bingjie, C. (2017). Evaluation of logistics competitiveness of logistics node cities in the western region. Journal of Southwest China Normal University (Natural Science Edition), (2017-02), 64-69.

Huiming, Z., Pengcheng, W., & Jicai, D. (2015). Spatial layout of logistics parks in Chongqing's main urban area and its impact on urban spatial structure. Geography Science, 35(7), 831-837.

Jiang, B., & Prater, E. (2002). Distribution and logistics development in China: The revolution has begun.International Journal of Physical Distribution & Logistics Management, 32(9), 783-798.

Kovács, G., & Kot, S. (2016). New logistics and production trends as the effect of global economy changes. Polish Journal of Management Studies, 14.

Kunpin, Z. (2007). Interaction Mechanism between Regional Logistics and Regional Economic Development. Journal of Hebei Forestry, 2007(3):168-171.

Lagorio, A., Pinto, R., & Golini, R. (2016). Research in urban logistics: a systematic literature review. International Journal of Physical Distribution & Logistics Management, 46(10), 908-931.

Lieb, R. C., & Lieb, K. J. (2015). The North American third-party logistics industry in 2013: The provider CEO perspective. Transportation Journal, 54(1), 104-121.

Liming, H. (2018). Review and Outlook of China's Logistics Industry in 2017. China's Circulation Economy, (2018 02), 3-7.

Lindawati, S., van, J., Goh, M. and Souza, R.de. (2014), “Collaboration in urban logistics: motivations and barriers”, International Journal of Urban Sciences, Vol. 18 No. 2, pp. 278-290.

Liu, J. (2018). Contemporary Logistics in China. J. H. Xiao, S. J. Lee, & B. L. Liu (Eds.). Springer Singapore.

Macharis, C., & Melo, S. (2011). Multiple views on city distribution: A state of the art. Cheltenham: Edward Elgar Publishing.

Macharis, C., Milan, L. and Verlinde, S. (2014), "A stakeholder-based multicriteria evaluation framework for city distribution", Research in Transportation Business & Management, Managing Freight in Urban Areas, Vol. 11, July, pp. 75-84.

Mengqiu, L., &Yu, C., &Yulin, L., Lu Mengqiu, Chen Yu, & Lu Yuxi. (2018). Space Competition Bureau of China's Land and Sea Transportation under the "Belt and Road Initiative". Geography Research, 37(2) , 404-418.

Pokharel, S. (2005). Perception on information and communication technology perspectives in logistics: A study of transportation and warehouses sectors in Singapore.Journal of Enterprise Information Management, 18(2), 136-149.

Qianqian, L., & Maochun, W. (2018). Empirical Analysis of the Impact of Logistics Industry in Guizhou Province on Economic Development Based on Logistic Model. Business Economics Research, (3), 50.

Quak, H. (2011). Urban freight transport: the challenge of sustainability. City distribution and urban freight transport: multiple perspectives, 37-55.

Rosenfield, D. B., Shapiro, R. D., & Bohn, R. E. (1985). Implications of cost-service trade-offs on industry logistics structures. Interfaces, 15(6), 47-59.

Sampaio, A., Savelsbergh, M., Veelenturf, L., & Van Woensel, T. (2019). Crowd-based city logistics. In Sustainable Transportation and Smart Logistics (pp. 381-400). Elsevier.

Shihua, M., 2005. Supply Chain Management [M]. Beijing: Mechanical Industry Press, 2005.

Shijin, W. (2013). Research on the Impact of Circulation Industry Development on Residents' Consumption. Beijing: China University of Mining and Technology PhD thesis

Shuang, L. (2010). Research on the coordinated development of China's logistics industry and national economy. Changsha: Ph.D. Thesis of Central South University.

Stathopoulos, A., Valeri, E. and Marcucci, E. (2012), "Stakeholder reactions to urban freight policy innovation", Journal of Transport Geography, Special Section on Rail Transit Systems and High Speed Rail, Vol. 22 No. 1, pp. 34-45.

TAC, 2002. Status and Trends of Foreign Logistics Development. Storage, transportation, and conservation of commodity. 2002(2).

TalkingData. (2017). Logistics industry report in 2017.

Taniguchi, E. (2014). Concepts of city logistics for sustainable and liveable cities. Procedia-social and behavioral sciences,151, 310-317.

Taniguchi, E. and Heijden, R.E.C.M.V.D. (2000), “An evaluation methodology for city logistics”, Transport Reviews, Vol. 20 No. 1, pp. 65-90.

Wang, J., Lim, M. K., Tseng, M. L., & Yang, Y. (2019). Promoting low carbon agenda in the urban logistics network distribution system. Journal of Cleaner Production, 211, 146-160.

Wei, Z. (2018). The Development Trend of China's Logistics Industry in the Era of "Internet Plus". Technical Economics and Management Research. 2018(4): 104-108.

Yi, C., & Hui, L., & Tao, S. Cheng Yi, Liu Hui, & Song Tao. (2018). Temporal and Spatial Patterns and Driving Factors of Foreign Economic Development in Southwest China. World Geography Research, 27(04), 77-89.

Yu Chunrong. (2008). Analysis of Logistics Demand in Jilin Province. Journal of Changchun University of Technology. 20(4): 6-9.

Zhao, X., Flynn, B. B., & Roth, A. V. (2007). Decision sciences research in China: current status, opportunities, and propositions for research in supply chain management, logistics, and quality management. Decision Sciences, 38(1), 39-80.

Zheng, H. (2014). Research on System Dynamics Model of Urban Traffic Congestion. Modern Economic Information. 21:383-386.