Citation: YUAN Quan, TU Yihuan, LI Guoqi. A Synthesized Logistics Network with Rapid-Response Strategies and Emergency-Management During the Pandemic [J]. Urban Transport of China, 2021 (2): 46–54.

A Synthesized Logistics Network with Rapid-Response Strategies and Emergency-Management During the Pandemic

YUAN Quan[1,2], TU Yihuan[3], LI Guoqi[3,4]

1. Key Laboratory of Road and Traffic Engineering, Ministry of Education, Tongji University, Shanghai 201804, China;
2. Urban Mobility Institute, Tongji University, Shanghai 201804, China;
3. School of Transportation and Logistics, Southwest Jiaotong University, Chengdu 610031, Sichuan;
4. National Engineering Laboratory for Comprehensive Transportation Big Data Application Technology, Chengdu 611756, Sichuan

Abstract: The logistics industry is not only the main force in fighting the COVID-19, but also one of the industries that has suffered the most during the pandemic. By discussing the types and characteristics of material demand, transportation modes, and bottlenecks in different regions during the pandemic, this paper summarizes the important role of the logistics industry in materials protection in key regions, domestic express delivery, and distribution, and coordinating international supply and industrial chains. The rapid-response strategies implemented by the logistics industry were largely dependent on effective policy making, efficient inter-industry networking and various logistics innovations. From the perspective of economic recovery and production resumption, the paper highlights multi-phase rapid-recovery strategies with particular focuses on key regions, key nodes, and key enterprises. Finally, the paper proposes an emergency-response logistics network system, in which participating entities, organizing institutions, operators and carriers, and information providers are integrated. **DOI:** 10.13813/j.cn11-5141/u.2021.0204-en

Keywords: transportation policies; urban logistics; emergency-response logistics network; emergency support; smart technologies; supply chain; COVID-19 pandemic

0 Introduction

The COVID-19 pandemic is characterized by widespread influence, strong transmission ability, and high pathogenicity. The pandemic has caused great impacts on the entire society and intensified the structure adjustment of the global economy and industrial division of labor. Among them, the disruptions and delays of supply chain and logistics operations are considered to be the key challenges faced by all countries, and can easily lead to humanitarian crises such as the shortage of health services, medical supplies, and food supplies, and hinder the global economic recovery [1-2]. Related issues have attracted the attention of many international organizations including the Food and Agriculture Organization of the United Nations, the World Health Organization, and the World Economic Forum[3].

The importance of logistics has been fully demonstrated in response to global public health crises such as the 2014 Ebola pandemic [4-5]. Relying on a professional, modern, and resilient network system, China's logistics industry has given full play to its advantages of strong mobilization capacity and wide application of intelligent technology and equipment. Through the joint participation and cooperation of the government, enterprises, professional institutions, and the public, it has not only provided an efficient guarantee for emergency medical aid and living supplies in emergency pandemic regions, but also effectively supported the procurement, transportation, and distribution of materials in other regions of the country.

With the spread of the pandemic to more than 200 countries and regions and the cumulative number of confirmed cases exceeding 100 million, logistics industries around the world have been seriously affected. However, China's logistics industry effectively overcame a series of shortcomings in the early response to the pandemic and played an important role in ensuring emergency medical supplies and the supply chain of living and production supplies in key regions. In

Received: 2020-06-30
Supported by: National Natural Science Foundation of China (71603219); Soft Science Project of Chengdu Science and Technology Bureau (2020-RK00-00224-ZF)
First author: YUAN Quan (1989–), male, from Ji'an, Jiangxi Province, PhD, associate researcher. Main research interests: urban transportation, urban logistics, traffic big data, and artificial intelligence. E-mail: quanyuan@tongji.edu.cn
Corresponding author: LI Guoqi (1984–), male, from Nanchang, Jiangxi Province, PhD, associate professor. Main research interests: logistics planning and regional sustainable development. E-mail: guoqi@swjtu.edu.cn

addition, the summary of the rapid-response and recovery strategies of the logistics industry under the impact of COVID-19 and a systematic understanding of the mechanism of the emergency-response logistics network operations can help to reflect on the shortcomings and deficiencies in the development of this industry. In this way, a high-standard emergency-response logistics system can be established [6-7].

1 The role and shortcomings of the logistics industry in pandemic response

Since the outbreak coincided with Chunyun, the world's largest annual human migration, most logistics enterprise employees were on vacation, and logistics parks, logistics centers, and large-scale warehouses were mostly in low-capacity operation, posing a huge challenge for pandemicresponse. In the joint prevention and control mechanism deployed by the State Council, the Ministry of Transport (MOT) and relevant departments set up the Logistics Support Office of the Material Supply Group as a means of overcoming key bottleneck factors (see Fig. 1) The departments took into full consideration the differences in material priorities, demand characteristics, and efficient transportation modes in different regions and adopted differentiated response strategies. For example, regarding Wuhan, Hubei Province, the center of the pandemic outbreak, the public sector worked together to establish five transfer stations for emergency supply transportation in the surrounding region and therefore met the needs for the transportation and turnover of emergency supplies. The "green channel policy" was also implemented to ensure the preferential and convenient access of transport vehicles without any parking, checking, and charging. With the effective response to the traffic during the operation of the logistics network, the online and offline integration was safeguarded. Hence, This research focusing on the key regional, national, and internationalspatial scales is conducive to a comprehensive understanding of the role and operation differences of the logistics industry in pandemic response.

1.1 Quickly improving the professional capacity of storage and transportation of key supplies in Wuhan and the Hubei Province

During the pandemic, a large number of medical and living supplies characterized by diverse types and high urgency were requested by Wuhan and other regions in Hubei Province. Relying on the efficient international and domestic logistics network, the whole nation had spared no efforts to overcome the key bottleneck challenges such as vehicle scheduling, inventory management, and "last-kilometer" delivery. Through various transportation modes such as road, railway, and aviation, a large number of supplies had been transported to Hubei providing strongsupport for social quarantine and centralized hospitalization. According to the statistics from the MOT, in the peak period of the outbreak(29 January–1 February), road and rail inputs were nearly three times higher than those in the flat period (17 February–8 March), with medical and living supplies accounting for more than 95% [9]. From a sub-category perspective, the main types and percentages of goods arriving in Wuhan between January 13 and February 12 were vegetables (61%), fruits (17%), food and beverages (14%), medical supplies (5%), and grains (3%) respectively [10]. Although the total freight volume entering Wuhan dropped by 75% after the city was locked down on January 23, the volume of medical supplies increased by 30% compared to a week earlier. Therefore, with the support of professional logistics, resources are concentrated in few key regions with a large gap between supply and demand. Moreover, it greatly helped relieve the pressure of supply shortage in pandemic control,medical treatment for patients, daily life, and social governance and gained time for the systematic fight against the pandemic at the national scale.

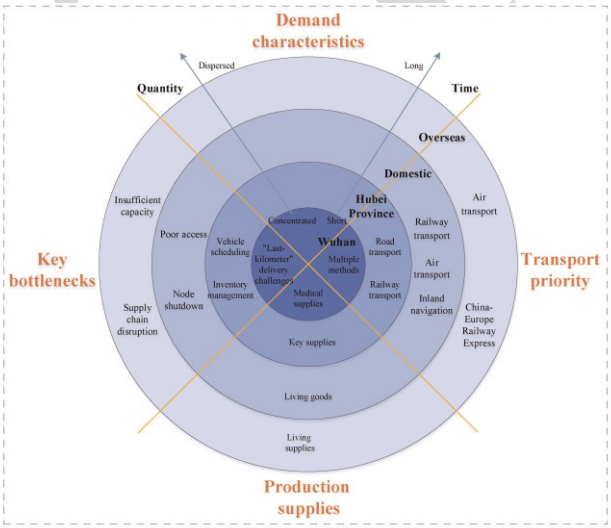

Fig. 1 Characteristics and bottleneck factors of logistics in different regional levels during the COVID-19 pandemic

1.2 Stable recovery of the normal express and the integration of storage, transportation, and distribution in major regions of China

Currently, online shopping has become the major channel of consumption for residents in China. In spite of the pandemic, the scale of online retail in China in the first quarter of 2020 was basically unchanged from the same period in 2019, with online retail sales of physical goods even increasing by 5.9%. Most residents relied on online shopping during home quarantine to minimize the risk of infection outside the home, posing challenges to the express delivery services and at the same time, exemplifying its advantages of low cost and efficiency while against the pandemic. In addition, the rapid development of new business modes such as takeaway, home delivery, and flash delivery has effectively helped the integration of online and offline sales and provided customers

diversified choices. The State Post Bureau launched a Level II emergency framework to improve the unified management and deployment of the emergency-response logistics system and established a mechanism to guarantee uninterrupted sending and delivery services. Meanwhile, the China Postal Express & Logistics (EMS) established a special air line to connect Wuhan with important cities including Beijing, Guangzhou, and Shanghai and timely provided urgently needed medical supplies for Wuhan. EMS, JD Logistics, and SF Express had been insisting on providing express services during the outbreak, and other express delivery enterprises resumed operations on February 10, ensuring the normal operations of express delivery services and gradually recovering the service capacity of integrated storage, transportation, and distribution.

With the network advantage long formed in express delivery services, the logistics industry responded to the huge demand along the supply chain of "manufacturers–e-retailers–consumers" during the special period. The industry in this way managed to minimize the impacts of the pandemic on the traditional supply chain of "manufacturers–wholesalers–retailers–consumers." The rapid-response capability, flexibility, and basic supply functions of the logistics industry have been intensively reflected in the process of supply chain reconstruction.

1.3 Gradually refilling the channel capacity to support the operation of international industrial and supply chains

As an important hub in the international supply chains and a major exporter of various goods, China has encountered problems including disruptions, capacity reductions, and in-transit lead time of the international logistics supply chains during the pandemic. The function realization of the industry requires synergistic cooperation among multiple departments [11]. In particular, the process coordination in logistic transportation involving customs, inspection, and quarantine has strongly supported the orderly and smooth flow of the global industrial and supply chains in this special period.

According to the mechanism for promoting the return to work set up by the State Council, the MOT, together with 12 departments including the Ministry of Foreign Affairs, the Ministry of Industry and Information Technology, and the Ministry of Commerce, set up a special collaboration framework on international logistics. A series of policies and measures were formulated to improve the international shipping capacity, including promoting the fast inspection and isolation of international freight crews, supporting the transportation of anti-pandemic supplies for foreign aids in all aspects, and solving the backlog of international mails. Examples were as follows. 1) China Post Group Co., Ltd. and China Ocean Shipping Group Co., Ltd. (COSCO Shipping) worked together under the framework to enhance demand matching and cooperate in mail delivery business by sea. International air cargo capacity were increased to encourage airlines to use passenger aircrafts as cargo carriers. 2) Improving the transportation capacity of the China-Europe Railway Express. From January to April 2020, China-Europe Railway Express ran 2,920 trains and sent 262,000 TEUs of goods, with a 24% and a 27% growth rate respectively; the heavy container rate reached 98%, and up to 660,000 pieces of anti-pandemic goods were transported. 3) the collaboration framework took effective measures to strictly control the quality of import goods and maintain market order through issuing information guidelines for foreign market access of anti-pandemic supplies, and strengthening the supervision of anti-pandemic supply exports. China had therefore successfully provided anti-pandemic and productionsupplies to the international community with quality and quantity.

However, in the process of fighting the COVID-19, China's emergency-response logistics system was also suffering from some shortcomings, particularly in three key links, two security systems, and one key region (see Fig. 2).

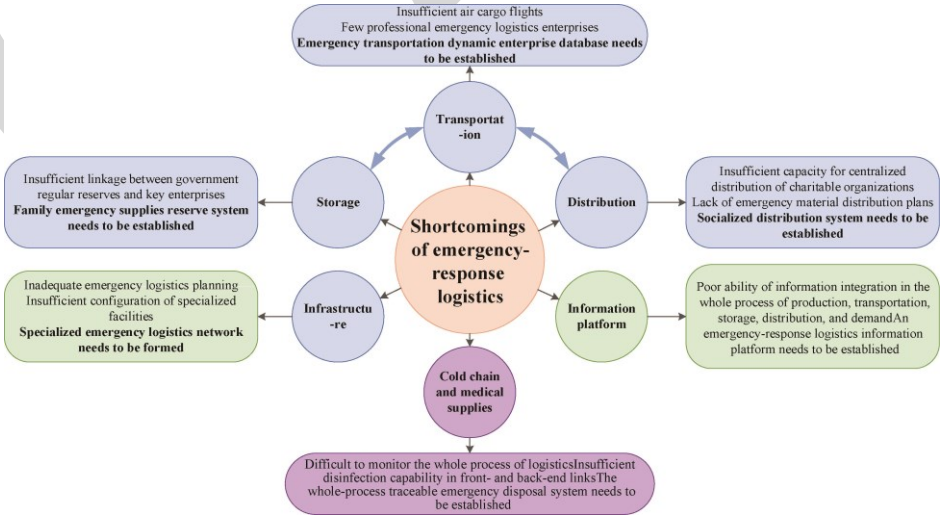

Fig. 2 Emerging problems in the current emergency-response logistics system during the COVID-19 pandemic in China

The three key links refer to the storage, transportation, and distribution of supplies. First of all, the existing storage of emergency-response supplieswere dominated by the government, with insufficient linkage to key enterprises and households, resulting in high storage costs and low willingness to storage in the private sector. Secondly, in the process of transportation, the number of air cargo flights and network coverage were inadequate, making short-term quick deployment highly difficult. Finally, in the process of supply distribution, charitable organizations such as the Red Cross did not equip themselves with professional staff, information systems, and plans to handle the management of large quantities of emergency supplies and thus failed to complete the complex and diverse distribution requirements in time.

The two security systems refer to the infrastructure and information platform. At present, the construction of emergency-response logistics infrastructure in China is mainly concentrated on the fields of grain and water conservancy. In the planning and construction of logistics parks, logistics centers, and other large-scale public logistics nodes, the emergency function and infrastructure configuration systems have not been fully considered. At the same time, in the construction of the public logistics information platform and emergency-response logistics system, the functions of collecting, processing, and releasing information has not yet formed for the whole process of production, transportation, storage, distribution, and demand, resulting in the lack of synergy between platforms.

The one key area refers to the cold chain and medical supplies. Since May 2020, the pandemic in Beijing, Shandong, and other places have been related to the cold chain link [8], which indicates that the whole-process monitoring system of emergency-response logistics in China has not yet been fully formed, and the front-end and back-end links have insufficient disinfection capabilities and thus brings about safety risks. To meet the urgent requirement of the COVID-19 vaccine distribution, emergency-response logistics plans and traceability systems should be designed in advance, and training for emergency-response logistics enterprises should be strengthened to prevent possible risks.

2 Rapid-response strategies of logistics network

During the COVID-19, the efficient operation of the logistics network relied on the close cooperation of transportation policymakers, logistics enterprises, and many other participants in the supply chain. The Chinese government issued a series of comprehensive policy plans and technical support measures involving nodes, channels, enterprises, and supplies as well as logistics storage, distribution, and information intelligence. With the support of policies, the core organizations of the logistics network (such as key enterprises and park management organizations) gave full play to their enthusiasm for emergency response to ensure the uninterrupted operation of the logistics network, and improve the response speed of the supply chain. By adopting efficient networking strategies and intelligent strategies, different types of emergency-response logistics needs were met in a timely manner (see Fig. 3).

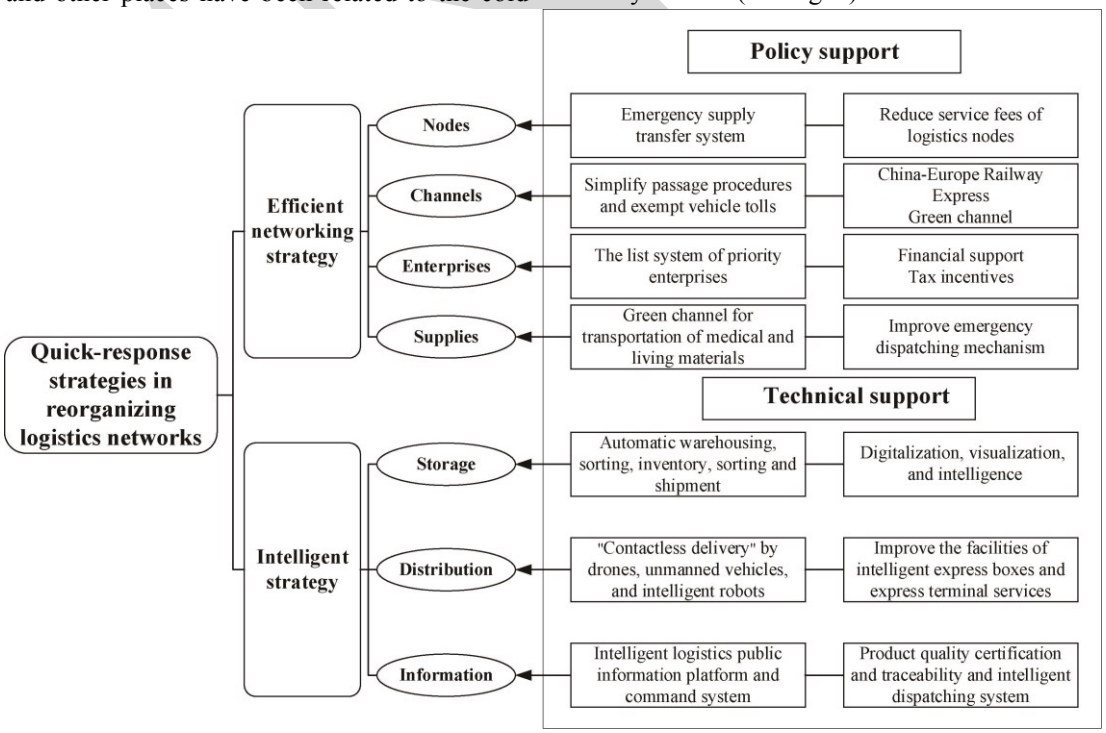

Fig. 3 Rapid-response strategies of logistics network

2.1 Enhancing efficient networking

In order to keep in touch with the worst affected areas, such as Wuhan and other regions, transportation management departments at all levels effectively coordinated with local governments to open up main channels around core nodes, rely on key enterprises, and guarantee key supplies to achieve efficient networking. The main initiatives are as follows. 1) Reducing service fees around core nodes to guarantee the normal operation of various distribution centers and logistics parks, and adding emergency supply transfer stations. At these stations, supplies were transshipped by drivers from affected areas in a non-physical-contact way, so the risks of driver infection could be reduced greatly. 2) Adopting the strategy of simplifying the passage procedures and exempting vehicle tolls to improve the transport efficiency of supply delivery vehicles. In addition, the container transport vehicles of the China-Europe Railway Express gained access to the "green channel" of emergency transportation, ensuring the smooth import and export of anti-pandemic supplies. 3) Establishing an inventory of priority enterprises and providing subsidies, supportive financing, and tax rebates to logistics enterprises operating essential goods circulation-related businesses. These measures provided a good institutional environment for the prevention and control of pandemics and the work resumption of enterprises. 4) Implementing the "green channel" policy for emergency supplies and important production and living suppliesin the pandemic prevention and control, giving priority to guaranteeing the quick passage of green-channel vehicles, and improving the emergency dispatching mechanism to ensure the orderly implementation of anti-pandemic work.

With the support of an efficient network, enterprises in many fields worked together, including manufacturing, transportation services, logistics platforms, express delivery, supply chain management, e-commerce, and storage infrastructure, and strived to improve the overall satisfaction rate of supply needs from front-end procurement, trunk line transportation, terminal distribution, and quality control. It succeeded to enhance the coordination and optimization control ability of the logistics network and improve the response speed and accuracy of demand.

Therefore, the reconfiguration of the logistics supply chain and reorganization of the logistics network in the context of the COVID-19 were a composite process involving multiple sectors, channels, modes, and industries. Under the support and coordination of the public sector, a special supply chain with structural toughness and mode flexibility was formed through the guidance and promotion of market demand, and an emergency-response logistics network with intensive scheduling and rapid-response was built. It should be noted that the positioning of public sectors needs to be clearly defined. To ensure that the networking can be completed within a limited time, public sectors need to make full use of organizational capabilities to complete the coordination of resource allocation, platform communication, and departmental collaboration. In particular, it is necessary to rely on cross-sector and multi-channel information collection, aggregation, and processing capabilities to ensure the establishment of a unified information platform. The platform is responsible for collecting, processing, and sending information and issuing coordinated instructions. Meanwhile, the smooth flow of information channels plays a key role in improving the efficiency of the networking. Finally, the emergency networking strategy should be institutionalized to form a unified action guideline and timely update the operation procedures.

2.2 Adopting intelligent applications

The crisis of COVID-19 has led to innovation in many industries and sectors, and the application of new technologies, such as the Internet of Things, big data, and artificial intelligence, etc.,has provided strong support for preventing the spread of COVID-19. The logistics industry has benefited from innovative transportation modes, advanced storage equipment, novel business models, and intelligent logistics data flow. Policymakers also focus on intelligent logistics development strategies.Through the deployment of the pandemic emergency-response logistics supply chain from various aspects including storage, distribution, and information, the efficiency of material supply can be ensured and the response speed of emergency-response logistics can be accelerated.

The dagitalization, visualization, and intelligence of storage promoted the wide application of automatic identification marking technologies such as intelligent tags and radio frequency identification, automatic or quick sorting technologies, and cargo tracking systems in the emergency storage of the pandemic. Meanwhile, financial and technical support was provided for the development of automated stereoscopic warehouses, automatic conveyor sorting systems, and automatic garages. Through the interlinking and interaction between human, machines, and information systems, the warehouses could automatically complete the storage, inventory, sorting, and delivery of goods, greatly enhancing productivity and operational efficiency. For example, in Cainiao's Guangdong warehouse, the Automated Guided Vehicles (AGVs) transported the goods to the storage location after receiving orders, and the operator only needed to supervise at the collection platform. Orders were picked up and then transported again by the AGVs to the packing area, reducing a large number of worthless displacements as well as the risk of virus transmission.

The quarantine policy for pandemic prevention and control gave birth to a "contactless delivery" modelas large delivery enterprises used the new generation of robots, drones, and autonomous vehicles to deliver goods. For instance, SF Express dispatched drones to distribute medical supplies in five cities including Wuhan, and these drones flew more than 13,000 km and completed more than 3,000 delivery services

within 32 days. In order to promote the "contactless delivery" model, the government actively improved the infrastructure of intelligent express boxes and express terminal services, and provided service operation subsidies for relevant express and takeaway delivery enterprises. At the same time, site planning and R&D trial operation were provided for distribution robots and drones, so as to strive to win the "last-kilometer" delivery battle during the pandemic.

Big data is an important data collection tool for logistics policy formulation as well as the key for logistics enterprises to predict logistics demand and make optimal decisions [12]. Through data collection and intelligent operation, the public information platform and command system of emergency-response logistics were established. At the same time, all kinds of product quality certification and traceability and intelligent dispatching systems were improved, which enhanced the integrity of government's information and the efficiency of decision-making. In order to accurately grasp demand and respond quickly, large logistics enterprises searched in their established supply chain networks and collected data from online and offline sources. For example, Suning Logistics created a warehouse space sharing program involving more than 100 logistics centers nationwide, and with the support of the Suning Cloud Warehouse, an intelligent logistics base driven by big data, it provided free national storage resources to local governments, hospitals, and charitable organizations during the pandemic and offered professional services for transshipment and storage.

The impact of the COVID-19 on the traditional supply chain has been unprecedented, so has the spawning of new businesses and new models. In similar public health events, the flow of goods is less sensitive than the flow of people to the impact on pandemic control, but there are also public health risks in the logistics process. Therefore, it is necessary to strengthen disease prevention at the source of logistics and reduce contact at logistics nodes, as well as to avoid inefficient and repetitive logistics activities and ensure the normal operation of the logistics industry. Therefore, the intelligent strategy can systematically improve the safety and efficiency of the emergency-response logistics network through three aspects. 1) The intelligent collaboration between the upstream and downstream of the supply chain can reduce efficiency loss caused by the insufficient coordination in the articulation process. 2) The automation in the logistics distribution process can reduce the safety risks at key nodes including express terminals. 3) The wide application of big data information can make up for the traditional deficiency of information asymmetry in the logistics network. It can be seen that intelligent technologies are both the fundamental requirements for the operating system of emergency-response logistics networks and the necessary choice for improving the marginal efficiency of core components.

3 Quick recovery strategy of logistics network

Logistics is the arterial system of national economy, linking all parts of the society to make them a whole, and is the driving force for the smooth flow of business [13]. In order to ensure the orderly operation of the economy, the logistics industry took the lead in resuming work and production from the pandemic. By adopting a recovery strategy that combines key regions, key nodes, and key industries of logistics, the key organizations and important goods carriers of the logistics network were functioning as the core to fully restore the logistics network. With the effective support of backbone logistics nodes and key enterprises, the recovery status of key logistics regions, key nodes, and key industries in different periods is shown in Fig. 4.

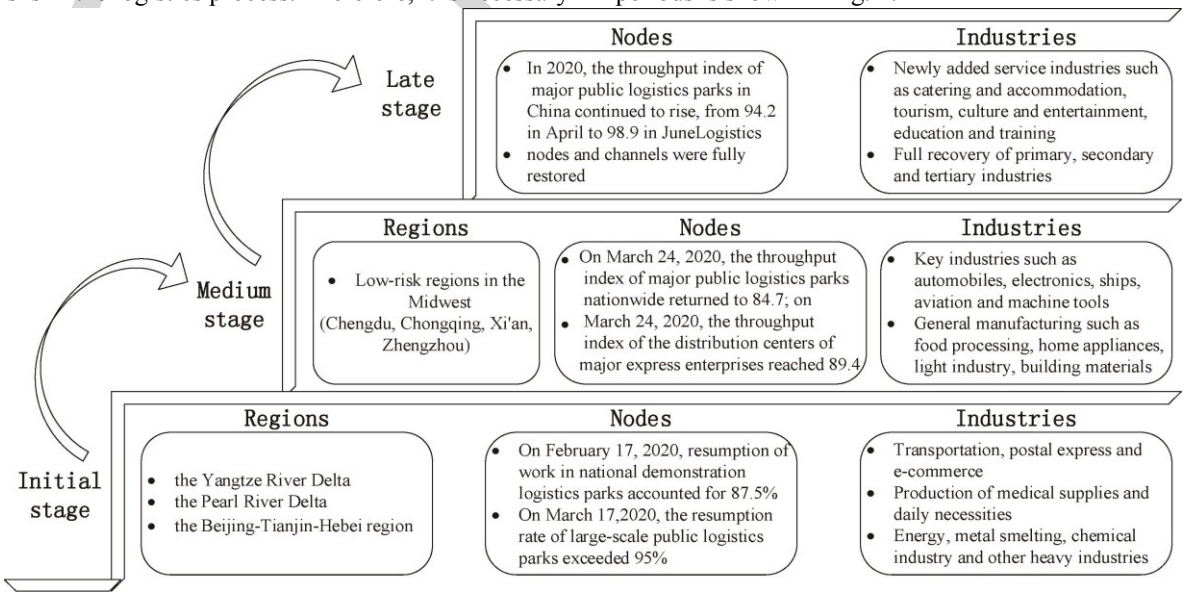

Fig. 4 Recovery status by regions, key sectors, and critical industries

3.1 Core and leading role of backbone logistics nodes

Logistics nodes such as logistics parks and centers are an important basis for the aggregation and distribution of goods. Enhancing the core and leading role of backbone logistics nodes is the key to the comprehensive recovery of the logistics network and national economy [14]. From February 10 2020, most regions across the country had entered the initial stage of work resumption, and low-risk regions became key recovery regions, especially the economically developed regions such as the Yangtze River Delta, the Pearl River Delta, and the Beijing-Tianjin-Hebei region. The government vigorously guaranteed the operation and recovery of large logistics hubs, logistics parks, and logistics centers, unlocked the passage of vehicles on national and provincial trunk routes, and gradually restored urban and rural road transport services. On February 17, 49 of the 56 national demonstration logistics parks started operation, accounting for 87.5% of the total number, and in the resumed parks, the median operation ratio of the resident enterprises was about 40%, among which 14 logistics parks reached more than 60%. On March 17, the resumption rate of large-scale public logistics parks nationwide exceeded 95%, providing a strong guarantee for the transportation and distribution of materials for enterprises and residents in the region. On March 20, most regions of the country were restored to low-risk regions and entered into the mid-term of work resumption. Important logistics node cities represented by Chengdu, Chongqing, Xi'an, and Zhengzhou in the central and western regions fully restored the operation in all logistics nodes. On the basis of the pandemic disinfection work and the prevention and control of the health-code personnel flow, logistics nodes were operated normally, and logistics channels continued to be unblocked. The throughput index of major public logistics parks across the country returned to 84.7, and the throughput index of the distribution centers of major express enterprises reached 89.4. On April 8, Wuhan officially lifted the outbound transportation restrictions. The whole country was restored to low-risk status, and the pandemic prevention and control entered a normalized stage. Meanwhile, the logistics nodes and channels were fully restored in all regions, and the throughput index of major public logistics parks in China continued to rise, from 94.2 in April to 107.1 in October, and the logistics network basically returned to normal.

The backbone logistics nodes represented by logistics parks are the core hubs of emergency-response logistics network organization, which play an important role in connecting upstream and downstream suppliers. Therefore, the backbone logistics nodes can deeply participate in the logistics management and optimization process, and the logistics flow, method, and spatial-temporal distribution were sorted out and integrated in a rapid-response manner to eliminate potential logistics bottlenecks and improve the dynamic capacity and stability of the whole network.

3.2 Important supportive role of key enterprises

Key logistics enterprises are the major players in the logistics network. It is of great significance to include those enterprises in the restoring process of the economy. In the initial stage of the work resumption, enterprises in certain fields took the lead in the recovery, including transportation, postal express, e-commerce, medical supplies and essential material production, and heavy industries such as energy, metal smelting, and chemical industries, ensuring the supply of medical, production, and living supplies. For example, as of March 12, Guangzhou postal express enterprises had basically resumed business, with a return rate of 98%. The average daily express volume was about 17 million, which had returned to the average level of 2019, and the average daily delivery volume was about 5.8 million pieces, which had returned to 94% of the average level in 2019.

In the mid-term of work resumption, in addition to the full recovery of important logistics enterprises such as storage, transportation, circulation and processing, and supply chains, all regions also vigorously promoted the recovery of key industries such as automobiles, electronics, ships, aviation, and machine tools as well as general manufacturing industries such as food processing, home appliances, light industry, building materials, and electronics. Such strategies created sustained and stable demand for regional logistics development, and drove the quick recovery of the logistics network. In April 2020, the Logistics Industry Prosperity Index in China was 53.6%, up 2.1% from March; the Express Logistics Index was 104.5%, up 0.8% from March; the E-commerce Logistics Operation Index was 107%, up 2.3% from March; the Manufacturing Purchasing Managers Index (PMI) was 50.8%, maintaining the overall economic rebound momentum. When all parts of the country were listed in low-risk regions and the prevention and control of the pandemic entered a normalized stage, the core task of economic recovery in each region was to continue to restore logistics and industrial manufacturing industries. At the same time, all regions should gradually restore service industries with high crowd concentration, such as catering, accommodation, entertainment, and tourism, so as to drive the creation of logistics demand, promote economic development, and strive to restore to the pre-pandemic level.

Local key enterprises are often the core kinetic energy in the industrial chain, which can drive the recovery of the whole industrial chain. Therefore, in the case of normalized control of the pandemic, local governments relied on industry associations to summarize the experience of key enterprises in combating the pandemic as soon as possible, so as to formulate the protection norms and implementation plans of emergency-response logistics organizations under different circumstances and establish a database of key enterprises for different types of disasters.

4 Reconstruction of emergency-response logistics networks

In the early stage of the fight against the pandemic, China's logistics industry was exposed to problems such as insufficient emergency supplies storage, poor specialization in the distribution of medical supplies, and inadequate allocation of logistics emergency infrastructure. By summarizing the effects of the rapid-response and recovery strategies and focusing on the core issues of participants, organizations, operation carriers, and information security, this paper proposes a design framework of the emergency-response logistics system (see Fig. 5). This system is developed from the perspective of systematic reconstruction of the supply and demand network of emergency-response logistics so as to improve the emergency-response logistics guarantee capacity and response efficiency.

In terms of supply network construction, the focus is to improve the information database of production enterprises and the three-tier supply storage system of government–enterprises–families, and therefore form a virtuous cycle system of supply storage and consumption. In the process of implementation, the government should pay attention to the dynamic information updates of production enterprises, and reasonably determine the policy subsidies for enterprises participated in storage. Then, the list of family storage supplies to the society should be timely released to mobilize the public to participate in the storage. In terms of demand network construction, the focus is to accelerate the establishment of demand-based real-time dynamic allocation methods to improve the efficiency of procurement and deployment Besides, closed centralized distribution and "contactless delivery" model, and regulations and norms for robot and drone operations should also be improved. Finally, it is important to build non-physical-contact service infrastructure such as intelligent express boxes and express terminal service sites, so as to promote the intelligent development of logistics and distribution. In the process of implementation, local governments at all levels should be encouraged to participate in information collection based on the public logistics information platform and the procurement and deployment of emergency supplies based on the joint distribution center. Meanwhile, the standardization and upgrading policies for non-physical-contact infrastructure should be introduced as soon as possible to encourage the construction of differentiated service infrastructure according to local conditions.

In order to achieve seamless connection and coordinated operation of supply and demand networks, the following six aspects can be considered. 1) It is urgent to build a database of emergency transportation and logistics enterprises, improve the professionalism of emergency transportation and logistics teams, and carry out normalized emergency drills, professional supply storage, and the construction of professional staff. 2) It is necessary to improve the emergency-response logistics hub system to form a professional emergency-response logistics network and focus on efficient switching with conventional networks to increase the efficiency of network utilization. 3) The government must accelerate the systematization of logistics channel construction, promote the development of multimodal transport, and lay stress on solving the bottleneck and capacity limitation of transport modes to raise the efficiency of intermodal transport evacuation. 4) Establishing the whole-process traceable emergency disposal system can upgrade the quality of cold chain logistics services and achieve full transparency of the logistics of key medical supplies. 5) The government needs to promote the deep integration of modern information technology and the construction of emergency-response logistics system and build a unified emergency-response logistics information platform. In this way, the effective connection among the national unified command platform of emergency-response logistics, local emergency logistics information platform, and enterprise logistics information platforms can be realized. Moreover, the interconnection mechanism of logistics nodes and comprehensive information among enterprises should be constructed. 6) It is also necessary to strengthen the integration capabilities of trunk line transportation, branch line transportation, and urban distribution [15] and enhance the integration of supply, demand, and transportation.

5 Conclusions

As the spread of the COVID-19 has not slowed down worldwide, and some countries that have successfully controlled the pandemic are facing the impact of the second pandemic, all countries in the world are facing the dual challenges of fighting the pandemic and recovering the economy. The logistics industry can provide important support in both aspects. Through studying the role of China's logistics industry, logistics network response strategies, and systematic network reconstruction, this paper believes that the multi-sectoral collaboration among government, enterprises, and industry associations is the organizational basis for the quick development of logistics networks. Second, the dedication and commitment of front-line grassroot workers such as couriers and truck drivers are the human resource basis for the full restoration of the logistics industry. Finally, big data technology and the innovative application of drones, unmanned warehouses, robots and, intelligent cabinets support the "connected but untouched" distribution mode, which effectively blocks the spread of the pandemic. In the comprehensive restoration process of the logistics industry, focusing on key regions, key nodes, and key industries has undoubtedly helped ensure the orderly operation of social and economic activities and reduce recovery costs. The reconstruction of the emergency-response logistics network system should focus on the future, and enhance the flexibility and

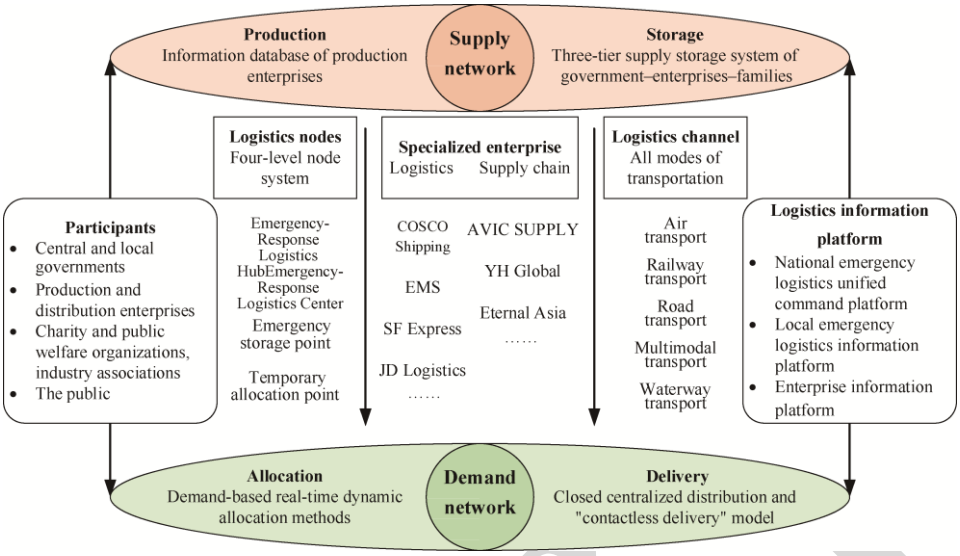

Fig. 5 A strategic framework for designing a comprehensive emergency-response logistics system

resilience for different types of emergencies, especially on improving the synergy and competitiveness of supply and industrial chains to achieve the normalization of response.

References

[1]Feng Gengzhong, Sun Yangyang.The Influence of COVID-19 on the Economy and Society from the Perspective of Supply Chain[J]. Journal of Xi'an Jiaotong University (Social Sciences), 2020, 40(4): 42-49 (in Chinese).

[2]Torero M. Without Food, There Can Be No Exit from the Pandemic[J]. Nature, 2020, 580(7805): 588–589.

[3]Hamilton P C. COVID-19 and Food Security in Vulnerable Countries[EB/OL]. 2020[2020-06-28]. https://unctad.org/en/pages/newsdetails.aspx?Original Version ID=2331.

[4]World Bank. The Economic Impact of the2014 Ebola Epidemic: Short and Medium Term Estimates for West Africa[R].Washington DC: World Bank Group, 2014.

[5]Gates B. The Next Epidemic: Lessons from Ebola[J]. The New England Journal of Medicine, 2015, 372(15): 1381–1384.

[6]Song Hua, Hu Dajian. Risk, Response and Prospect of Supply Chain in the Situation of Coronavirus Outbreak: Summary of the "Emergency Supply Chain Management and Public Safety" Online Conference[J]. Supply Chain Management, 2020, 1(2): 5-11 (in Chinese).

[7]Zhu Ye. Strategies of Emergency Material Transportation Under Public Health Emergencies[J]. Urban Transport of China, 2020, 18(5): 102-109 (in Chinese).

[8] Jia Xiaohong, Niu Weikun, Sun Leqi. Beijing:外卖、快递、餐饮等人员必须全面检测 [N/OL]. Beijing Daily. 2020[2020-06-28]. http://www.thecover.cn/news/4542759(in Chinese).

[9]Pan A, Liu L, Wang C, et al. Association of Public Health Interventions with the Epidemiology of the COVID-19 Outbreak in Wuhan, China[J]. JAMA, 2020, 323(19): 1915–1923.

[10] Manbang Freight Big Data: The supply of guarantee materials in Hubei is stable, and vegetables are "just needed" [N/OL]. China News. 2020[2020-06-28]. https://baijiahao.baidu.com/s ?id=1658860826410814147&wfr=spi -der&for=pc (in Chinese).

[11]Yang Tao, Hu Yueping, Wang Zhongqiang, et al.Urban Freight Transportation and Urban Healthy Development: The 4th Chinese Urban Transportation Development Forum in 2018[J].Urban Transport of China, 2019, 17(1): 109-120 (in Chinese).

[12]Wang Guangtao.Urban Transportation and Informatization[J].Urban Transport of China,2015,13(3):1-4 (in Chinese).

[13]Ye Huaizhen.Modern Logistics[M].Beijing: Higher Education Press,2019 (in Chinese).

[14]Li Guoqi, Sun Wenjie, Yuan Quan, et al.Planning Versus the Market: Logistics Establishments and Logistics Parks in Chongqing, China[J]Journal of Transport Geography, 2020, 82, 102599.

[15] Liu Chen, Li Yue, Zhang Libin, et al. Transform the efficient operation mechanism of emergency logistics into the usual efficient operation capability [EB/OL]. 2020[2020-06-28]. http://www.zgcsb.com/jiaotong/202003/06/content_157534.html (in Chinese).