Scientific Research Publishing

Advances in Internet of Things, 2022, 12, 110-123
https://www.scirp.org/journal/ait
ISSN Online: 2161-6825
ISSN Print: 2161-6817

The Study on the Framework and Implementation Scheme of the Railway Intelligent Cold Chain Logistics System

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How to cite this paper: Xu, W., Li, G. and Li, X.F. (2022) The Study on the Framework and Implementation Scheme of the Railway Intelligent Cold Chain Logistics System. *Advances in Internet of Things*, **12**, 110-123.
https://doi.org/10.4236/ait.2022.123007

Received: June 8, 2022
Accepted: July 23, 2022
Published: July 26, 2022

Abstract

With the development of intelligent and communication technology, traditional logistics has gradually transformed into intelligent logistics. The construction of the railway intelligent cold chain logistics system is an effective measure to implement the structural adjustment of supply, which conforms to the times. Firstly, basic features and design principles of the railway intelligent cold chain logistics system were described. Secondly, target functions and the system framework of the railway intelligent cold chain logistics were put forward, which takes information service as a foundation, management service as a guarantee, business capability as kernel and expansion capability as support. Subsequently, the technical approaches were studied at the hardware, processing and software levels. Finally, development strategies of the railway intelligent cold chain logistics were discussed, including optimizing the layout of infrastructure, improving the performance of equipment, extending the reach of services, deepening the cooperation of technologies and promoting the formulation of standards which provides feasible references for the railway cold chain logistics to explore modern business models.

Keywords

China Railway, Cold Chain Logistics, Intelligent Logistics System, System Framework, Scheme Design

1. Introduction

With the progress of technologies such as network communication, geographic information and data mining, intelligence has become the trend of modern lo-

gistics [1] [2]. Driven by science and technology, the transportation industry should pay more attention to long-term strategy and planning through top-level design [3].

In order to meet the market demand and improve competitiveness, railway cold chain logistics has been embracing reform and innovation in recent years, and the freight volume of railway cold chain logistics in China has been growing steadily [4]. The railway cold chain logistics has been well studied to enhance the specialization and achieve high-quality development. Taking benefits as the key, improvement measures and reasonable suggestions were put forward in the field of operation management, which includes market dynamic monitoring [5] and intelligent decision supporting [6]. Taking coordination as the principle, configuration approaches and upgrading ideas were put forward in the field of transportation equipment, which includes improving efficiencies of general equipment and taking advantage of specialized equipment [7]. Taking efficiency as the purpose, construction methods and layout schemes were put forward in the field of corridor planning, which includes traffic assignment [8], layout optimization of logistics network [9] and design of logistics park [10].

At present, in terms of intelligent and total service, there are still some deficiencies in railway cold chain logistics, such as low business integration and poor market flexibility. Based on applications of Internet of Things technology, many scholars have been concerned with railway intelligent cold chain logistics. Chen, Q. and Ji, R. T. [11] studied the construction of an intelligent service system for railway cold chain logistics of China Railway Taiyuan Group Co., Ltd., and put forward the system development mode with online and offline integrated networks. By using GPS, RFID, NB-IoT and other modern technologies, Lin, C. Z. [12] discussed the intelligent design of railway cold chain logistics from the perspective of market competition.

Existing studies are either limited to regional railway cold chain logistic or lack further analysis of the core management systems. It is of great significance to construct the railway intelligent cold chain logistics system from the wider level. Based on the brief description of basic features and design principles of railway intelligent cold chain logistics, the system framework was proposed in this study. Aiming at the intelligent development of railway cold chain logistics, technical approaches and development strategies of the system were put forward.

2. Basic Features and Design Principles

Based on smart software and hardware, Intelligent Logistics System (ILS) could realize dynamic operation and precise management at all stages of logistics activities with the help of Internet of Things technology and big data applications [13]. Combining the current situation of railway cold chain logistics with the advantages of ILS, the basic features of railway intelligent cold chain logistics could be analyzed: Based on these basic features, design principles of the system were proposed in terms of information, management, business and expansion.

2.1. Basic Features

Flexibility and marketization: By focusing on the market development closely, the existing technical solutions and organizational forms based on consumer demand and supply capacity could be flexibly adjusted. Considering the differences in cold chain logistics between various regions, the resources of railway cold chain logistics could be rationally allocated according to many factors such as traffic conditions, economic environment and consumption levels.

Hierarchy and quality: According to requirements management and hierarchical relationships, operation steps of railway cold chain logistics could be coordinated with each other by dealing with regional logistics demands properly and strengthening the connections between logistics nodes effectively. Taking seven "rights" of logistics [14] as the principle, operators should fully consider the actual requirements of participants, further optimize the control of costs so as to provide customized services and realize the Economic Order Quantity (EOQ) [15].

Digitization and intellectualization: Based on the "95306" railway freight service platform, China Railway would continuously enhance the integration of the logistics network and the Internet and promote timely updates and interactions of cold chain logistics information. Digital platforms and intelligent equipment could be used as the basis of software and hardware respectively, and intelligent technologies should be deployed and applied in process control, auxiliary decision-making and result evaluation to enhance the quality control and in-transit monitoring of refrigerated goods.

Agency and synergy: Optimizing the layout of the supply chain, eliminating barriers of information between upstream and downstream firms, and cooperating with third-party logistics channels, are possible approaches to extend service scope and improve service efficiency. Through the overall deployment of existing transport capacity, connections between production and consumption would be established in time, then the coherence of railway cold chain logistics between long-distance transportation and terminal distribution could be improved, which would bring win-win results finally.

Greening and internationalization: Following the concept of environmental protection and resource sharing, storage and transportation equipment of railway cold chain logistics should be updated or upgraded on demand, then the energy efficiency would be raised to reduce redundancy and avoid waste. With reference to international standards and specifications, the standard system of China Railway in the field of cold chain logistics could be improved. By developing high-quality cross-border logistics such as the "China-Europe Railway Express" [16], the "Belt and Road Initiatives" and the "go global" strategy of China Railway would be further implemented.

2.2. Design Principles

Complete information service would be the foundation for the stable operation

of the system. The network layout, information releasing, data processing and transaction management should be considered as a whole so as to increase the interactivity and stability of the system. The system should timely release the information on transportation resources such as refrigerated containers and rolling stock, and online transactions could be realized conveniently through Internet terminals. Furthermore, information services could provide release interfaces for suppliers and query interfaces for demanders. Besides the function of online presentation, offline service centers should be selectively set up according to developments in railway cold chain logistics in various regions.

Hierarchical management service would be the guarantee for the scientific deployment of the system. Business management, financial analysis, resource planning, credit evaluation and security monitoring are important components of the modern management system. On the basis of information security, the railway intelligent cold chain logistics system should be connected with information systems of cooperative enterprises to realize information interaction and resource sharing. Then information tracing services could be provided according to the tracking system of trains. The transfer process should be properly managed according to the railway operating plan. Through the system, the automatic and intelligent management level of railway cold chain logistics could be further improved in train schedules, security inspection and route planning.

The reliable business capability would be the kernel of the long-term development of the system. Intelligent logistics services involve many fields such as data analysis, marketing management and financial investment. New profit growth points could be sought through cooperation with social capital and research institutions. The business model combining online and offline services should be adopted, and improved or newly designed refrigerated cars should be put into service. Business outlets, freight centers and logistics bases should be managed as network nodes, and technologies such as big data, the Internet of Things and cloud computing should be fully applied. Logistics processes could be optimized by strengthening industrial collaboration between upstream and downstream enterprises. Through cooperation with trading companies, logistics enterprises and research institutions, a comprehensive platform for railway cold chain logistics could be established.

The innovation of the service model and the extension of the business scope mainly depend on the expansion capability of the system. In the process of designing and constructing the system, the expansion requirements of new businesses and emerging technologies should be considered to make the overall planning and step-by-step implementations. As business volume increases, the banking and financial systems could be combined with railway intelligent cold chain logistics to provide logistics financial services including credit rating and inventory loans. The system should provide value-added services according to the transport capacity. Online consumption demands for high-value-added commodities could be transformed into logistics services. Through cooperation

with financial firms and medical institutions, services such as online investment and health consultation could be provided.

3. Target Functions and the System Framework

The target of the railway intelligent cold chain logistics system is to realize the intelligent applications of cold chain logistics based on Internet of Things technology. Functions of the system could be analyzed according to application scenarios and target customers. Driven by target functions, components of the system and relationships between them were discussed. From the level of the overall structure and core management, the framework of the railway intelligent cold chain logistics system was put forward.

3.1. Target Functions

The target of the railway intelligent cold chain logistics system is to realize the intelligent applications of cold chain logistics based on Internet of Things technology, mainly including:

Automatic monitoring: With the help of sensors, the environmental parameters of the refrigeration house and transportation equipment could be collected in real-time [17]. And the corresponding devices would automatically alarm and make adjustments when the environment deviates from appropriate conditions.

Intelligent warehousing: Making full use of Internet of Things technology, intelligent warehousing could realize the intelligent operation of refrigerated goods in many processes such as inventory control, location assignment and access management.

Intelligent transportation: Taking advantages of information sharing, optimized distribution schemes could be formulated by integrating supply and demand information of social cold chain logistics with railway freight resources.

Commodity presentation: Customers could obtain comprehensive information about commodities through Virtual Reality technology, interact and communicate with suppliers and other customers conveniently, then transactions could be completed by online payment.

Information tracing: The quality supervision system of the whole process could be established by using key technologies such as Radio Frequency Identification (RFID) and Database Administration (DBA). With the help of production and circulation archives, regulators and operators could control the quality and safety of commodities appropriately.

Process tracking: Technologies such as Geographic Information System (GIS), Global Positioning System (GPS) and Global System for Mobile communications (GSM) could be applied to track the locations of cars and get information about refrigerated goods during transportation so as to strengthen the management of logistics [18].

Value-added services: Based on railway cold chain logistics, inspection and testing, freight forwarding, online marketing, credit investigation and other val-

ue-added services could be provided to inspection and quarantine authorities, social logistics enterprises, agricultural producers, financial institutions and insurance firms.

3.2. System Framework

1) Overall structure

The railway intelligent cold chain logistics system mainly includes the integrated management subsystem and the business operation subsystem, as shown in Figure 1. According to the different stages of logistics data, the system could be divided into the operating environment layer, the data center layer, the technology platform layer, the integrated business layer, the comprehensive management layer, the access control layer and the terminal application layer.

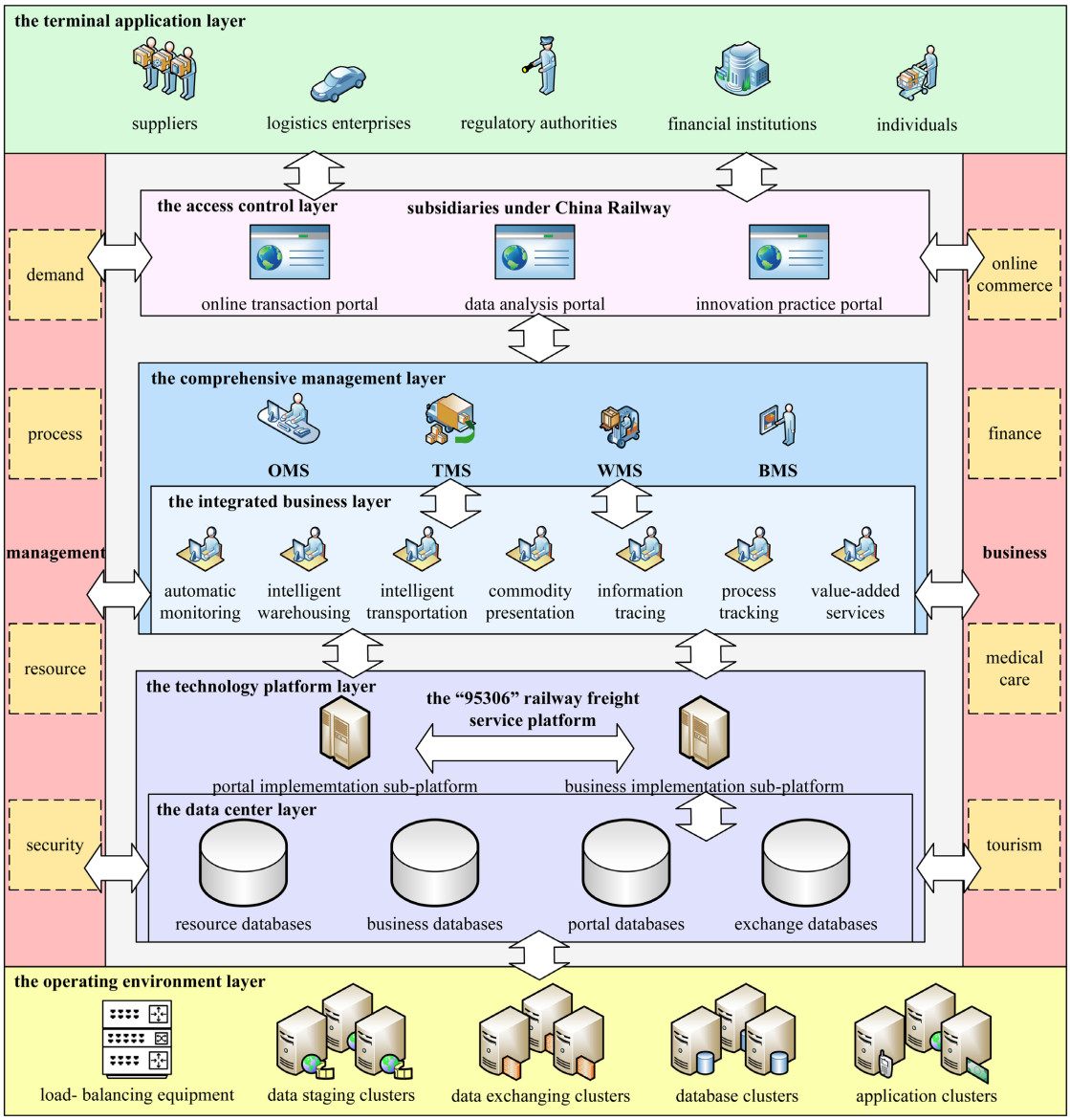

Figure 1. The overall structure of the railway intelligent cold chain logistics system.

The operating environment layer consists of computing clusters and network links, and the data center layer consists of resource databases, business databases, portal databases and exchange databases. Based on the data center layer and the "95306" railway freight service platform, the portal implementation sub-platform and the business implementation sub-platform could be established. According to requirements of operation and management, loose coupling among business components should be applied at the comprehensive management layer to achieve the unified deployment and flexible configuration of various functions. Subsidiaries under China Railway could connect with suppliers, logistics enterprises, regulatory authorities, financial institutions and individuals via the access control layer. Terminal users should follow the principles of sharing and security to access management or auxiliary applications.

Relationships between processes and between participants would be considered simultaneously. Through centralized scheduling, the circulation processes could be shortened. Thus transfer efficiency would be improved and intermediate costs would be reduced. In order to avoid shortages or surpluses of goods, the expected supply and demand of the refrigerated goods market and the transport capacity of railway cold chain logistics could be monitored in real-time through big data applications. Data in various forms or with different dimensions would be cleaned, summarized and structured; then systematical analysis could be conducted with the help of machine learning methods. The scenarios of railway cold chain logistics in different processes would be simulated, and the optimized solutions could be proposed by using Artificial Intelligence (AI) algorithms. In addition, with the continuous growth of demands, the amount of accumulated data would increase accordingly. By using these historical data, functions of auxiliary decision-making could be strengthened, which would effectively increase efficiency and reduce costs of railway cold chain logistics.

2) Core management systems

In the railway intelligent cold chain logistics system, core management systems of the comprehensive management layer include Order Management System (OMS), Transportation Management System (TMS), Billing Management System (BMS) and Warehouse Management System (WMS), as shown in **Figure 2**.

Through cooperation with suppliers, OMS and WMS would link production, warehousing and consumption, inventory could be determined according to EOQ, and Make-to-Order (MTO) strategy [19] could be applied in production. Through cooperation with financial institutions, WMS and BMS would link warehousing and processing. With the help of credit guarantees, storage prices would be adjusted to improve the added value of refrigerated goods. Through cooperation with transportation enterprises, BMS and TMS would link production, transportation and consumption. With the help of multi-modal transportation, "the first and the last kilometers" services would be improved to reduce circulation costs. Through cooperation with regulatory authorities, TMS and OMS would link warehousing and transportation. According to the principle of

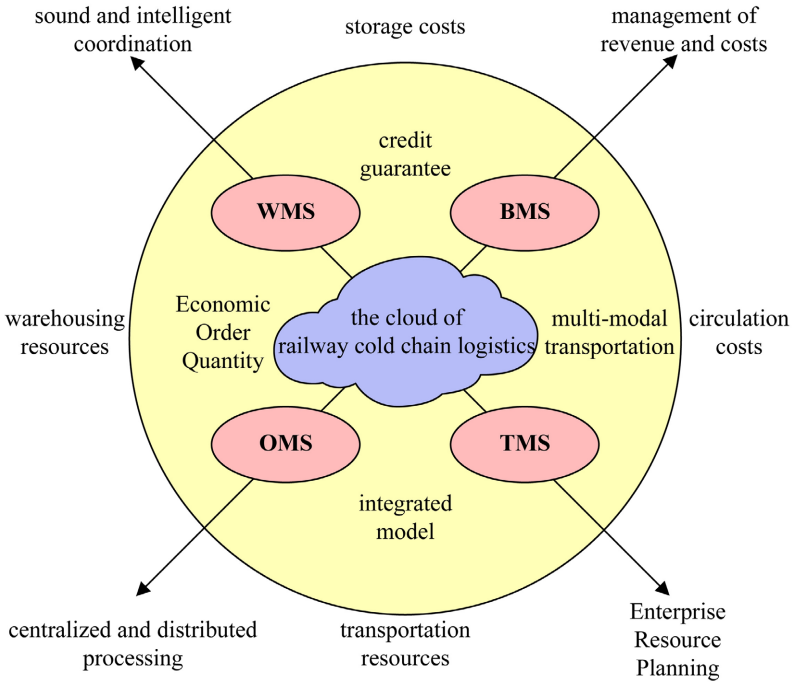

Figure 2. Core management systems of the comprehensive management layer.

integration, the transport capacity could be properly allocated and the quality control of intermediate processes could be effectively strengthened.

Core management systems should be independent and interrelated. Taking the cloud of railway intelligent cold chain logistics as the link, they would be integrated through the information chain and the value chain under cost constraints so as to seek the rational allocation of warehousing resources and transportation resources, as well as the appropriate balance between storage costs and circulation costs.

4. Technical Approaches and Development Strategies

4.1. Technical Approaches

The implementation approaches of railway intelligent cold chain logistics systems could be analyzed from the levels of hardware, processing and software.

1) Hardware level

Production equipment: Production equipment includes handling equipment, warehousing equipment, transportation equipment and so on, which could improve the efficiency of operation and production in railway cold chain logistics through technologies such as the Internet of Things, digital communication and remote control. For example, gantry cranes could automatically identify containers and flat cars with digital labels, and determine their positions in real-time. And mechanical arms could be remotely controlled to realize accurate liftings of containers.

In terms of warehousing services, intelligent and automated warehouses could be built to realize the overall arrangement of warehousing, picking, handling and

stacking, as well as the positioning and tracking of pallets and forklifts. Augmented Reality (AR) technology could be applied to assist workers in completing corresponding operations in the form of visual instructions. In terms of transportation services, cold chain express trains should be deployed in time and the advantages of mainline railways should be further leveraged. Timely interaction of logistics information, automatic tracking operation of trains and Product Lifecycle Management (PLM) could be realized by means of Internet of Things technology, 5th Generation mobile communication (5G) and big data applications [20].

Safety equipment: Safety equipment includes inspection equipment and protective equipment, which could improve the efficiency of safety supervision in railway cold chain logistics through technologies such as RFID [21], intelligent perception and information tracing.

In terms of security inspection, the equipment could integrate functions such as registration, inspection and weighing to increase the turnover efficiency and decrease the in-transit loss of refrigerated goods; thus the quality of service could be improved. In terms of hazard identification, equipment such as temperature sensors, smoke alarms, metal detectors and video recorders could be deployed in freight yards, freight trains and containers to realize online identification and intelligent alerting of hazards. In terms of risk tracing, digital labels, wireless communications and data-exchanging equipment could be deployed to record the information of refrigerated goods and logistics processes in the form of images, videos and data tables, so as to improve the reliability of risk tracing.

2) Processing level

Collection technology: Based on the sensor network, the collection technology could obtain the main information of logistics elements with the help of digital labels and sensing equipment. For refrigerated goods, digital labels and corresponding sensing equipment should be deployed according to different categories and logistics processes, so as to accurately control the temperature and humidity environment in railway cold chain logistics.

Identification technology: The system could obtain key features of multimedia information and achieve accurate descriptions of logistics elements through identification technologies such as dimensionality reduction and intelligent augmentation. For operating in freight yards and monitoring in transit, the status of freights, personnel and equipment could be timely feedback through identification technology.

Positioning technology: Based on the geographic information database, the positioning technology could collect location data by means of satellite communication and motion monitoring to realize real-time feedback on the spatial states of logistics elements. For freight trains, road transport vehicles and refrigerated goods, the spatiotemporal positioning technology could be adopted to monitor their locations in real-time, so as to obtain the overall information on railway cold chain logistics.

Optimization technology: Based on the data analysis, the intelligent optimiza-

tion technology could achieve situational deductions and provide reasonable suggestions by means of data mining and big data applications. Through data interpretation and regression analysis, development trends of the cold chain logistics market could be extrapolated. By using AI algorithms, optimized solutions for equipment configuration and process design could be generated [22].

3) Software level

Network interconnection: make full use of the Internet to strengthen interactions between logistics nodes at the spatial level, and enhance the consistency of logistics activities at the temporal level. Data could be processed locally or in the cloud by means of information monitoring, data mining and trend extrapolation, and decision results could be intelligently applied through base stations, digital switches and electromechanical controllers.

Business integration: The production and consumption of commodities should be included in the whole-process logistics, and corresponding facilities should be set up at sources and sinks to improve "the first and the last kilometers" distribution from the overall perspective [23]. According to the requirements of integrated operation and hierarchical management, on the basis of modern technologies, the service capabilities of railway cold chain logistics could be improved by means of external gathering, internal distribution and business subcontracting.

Dynamic management: Through the rolling analysis of historical and current business, the turnover of freight flow, capital flow, information flow and service flow could be dynamically evaluated. Aiming at weakness, the management level should be gradually improved and the technical equipment should be systematically upgraded. Taking railway cold chain logistics as the core, online transactions, credit guarantees and other customized services could be provided for enterprises or individual customers. By using data mining and analysis technologies, market monitoring and dynamic alerting could be realized.

Information interaction: Relying on the digital platform of intelligent logistics, the data generated in production, processing, warehousing, transportation and consumption would be collected and analyzed to promote interactions of logistics information among participants, and the whole-process optimization of railway cold chain logistics could be achieved. From the perspectives of producers, traders, distributors and individuals, the whole-process information chain integrating logistics and value-added services should be constructed, then intelligent applications of railway cold chain logistics in transportation, warehousing, transactions and management could be developed.

4.2. Development Strategies

Based on the analysis of technical approaches, the development strategy of railway intelligent cold chain logistics could be discussed from the aspects of infrastructure, equipment, services, cooperation and standards.

According to the distribution of supply and demand in the cold chain logistics market, modern refrigeration houses and hierarchical processing centers could

be set up in producing areas, and logistics zones and distribution centers could be set up in consumption areas. Based on "The 13th five-year development plan for the layout of railway cold chain logistics network" [24], planning focused corridors and establishing multi-level bases would further improve the network of railway cold chain logistics. Refrigerated freight trains could be scheduled to take full advantage of long-distance transportation. In order to shorten the circulation process of commodities and create a full-service system of cold chain logistics, China Railway could ally with agricultural wholesale markets and e-commerce platforms.

By introducing technologies such as the Internet of Things, modern communication and AI into railway cold chain logistics, the informatization and automation upgrading of existing equipment and facilities could be promoted. It is also important to speed up the development of new equipment, such as energy-saving and environment-friendly containers with functions of temperature, humidity or gas adjustments, so as to realize the in-transit monitoring and information tracing of commodities. In order to improve the market competitiveness, it is necessary to actively explore the application of simulation, machine learning and decision support system in the field of railway cold chain logistics, such as the simulation of multi-modal transportation, the feature learning of target customers and the formulation of railway operating plan.

Through the Intelligent Cloud Service of railway cold chain logistics, the information barriers between railway cold chain logistics and financial, medical and tourism industries would be eliminated. By improving Supply Chain Management (SCM), the convergence of freight flow, capital flow and information flow would be promoted to meet the special and customized demands. With the help of big data analysis, the Internet of Things, Virtual Reality (VR) and other technologies, enterprise users could obtain services such as transaction query, cost control and market prediction, and individual users could obtain services such as information tracing and experiential consumption. Eventually, intelligent logistics solutions for multi-functional scenarios such as finance, tourism and medical treatment would be formed.

Relying on the "95306" railway freight service platform, the relationship between railway cold chain logistics and social logistics enterprises, e-commerce and manufacturers could be further strengthened through cooperation in marketing, distribution, quality control and cross-border logistics. With the help of Intelligent Cloud Service of railway cold chain logistics, the whole-process intensive management of order-based production, online marketing, multi-modal transportation and regional distribution could be realized, then the service efficiency would be improved [25]. Furthermore, the railway cold chain logistics technology innovation center could be jointly established by inviting colleges, universities, social enterprises and scientific research institutions. By cooperating in key and frontier domains, the virtuous cycle of production, operation and innovation would be promoted.

In-transit monitoring, transfer efficiency and quality control are important

factors that determine the cost of cold chain logistics. Under the joint supervision of government departments and the market, China Railway should consider development objectives and operating conditions of railway cold chain logistics, and participate in the formulation of technical standards or service specifications for infrastructure construction, equipment application and process optimization. By accumulating service data and analyzing feedback information, appropriate parameters or methods for key logistics operations such as warehousing, picking, packaging, and transportation could be determined intelligently so as to realize the standardization of railway cold chain logistics and promote the overall benefits of the cold chain logistics industry [26].

5. Conclusion

In the wake of developments in the digital economy and intelligent technology, intelligent logistics centered on automatic control system and decision support system has become the mainstream. The growing market demand, diversified consumption structure and advanced professional technology not only provide favorable external conditions for business capacity upgrading and service model reforming but also put forward higher requirements for railway cold chain logistics on strategic deployment and operation management. In the process of promoting the intelligent transformation of railway cold chain logistics, following the principles of matching targets and requirements, adapting structures to functions and coordinating operation and management, building a framework with reasonable layouts and full functions is of great significance for realizing the high-quality development of railway cold chain logistics.

Acknowledgements

This study was funded by the National Railway Track Test Center, China Academy of Railway Sciences Corporation Limited (No. 2021SYJJ01).

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] He, L.M. (2017) The Development Trend of China's Smart Logistics. *China Business and Market*, **31**, 3-7.

[2] Mcfarlane, D., Giannikas, V. and Lu, W.R. (2016) Intelligent Logistics: Involving the customer. *Computers in Industry*, **81**, 105-115. https://doi.org/10.1016/j.compind.2015.10.002

[3] Wang, Q.Y. and Mao, B.H. (2020) Impacts of Science and Technology on Transportation. *Journal of Transportation Systems Engineering and Information Technology*, **20**, 1-8+36.

[4] Cold Chain Logistics Committee of CFLP, National Engineering Research Center for Agricultural Products Logistics, Shenzhen E6 Technology Co., Ltd. (2021) China

Cold Chain Logistics Development Report. China Fortune Press Co., Ltd., Beijing, 99-110.

[5] Wang, Y. and Lu, X. (2021) Random Forest Regression Model Application for Prediction of China's Railway Freight Volume. In: Hernández, J.E., Li, D., Jimenez-Sanchez, J.E., Cedillo-Campos, M.G. and Wenping, L., Eds., *Collaborative Logistics and Intermodality*, Springer, Cham, 91-120. https://doi.org/10.1007/978-3-030-50958-3_6

[6] Zhao, C.L., Meng, Y.B., Liu, J.B., Xiong, W. and Qiao, P. (2018) Dispatch Model and Solution Strategy for Multimodal Transportation Based on Logistics Cloud Platform. *Journal of the China Railway Society*, **40**, 1-8.

[7] Miao, B.R., Zhang, W.H., Liu, J.X., Zhou, N., Mei, G.-M. and Zhang, Y. (2021) Review on Frontier Technical Issues of Intelligent Railways under Industry 4.0. *Journal of Traffic and Transportation Engineering*, **21**, 115-131.

[8] Xu, W., Li, X.F., Li, G. and Zhao, B. (2021) Supply-Demand Forecast and Traffic Assignment of Market-Oriented Railway Cold Chain Logistics. *China Transportation Review*, **43**, 103-107.

[9] Zhang, C. and Liu, S.C. (2021) Research on Layout Optimization of Multi-hub Hybrid Hub and Spoke Railway Cold Chain Logistics Network. *Journal of the China Railway Society*, **43**, 1-9. https://doi.org/10.1155/2021/8830561

[10] Wu, Z.W. (2020) A Study on Internet of Things Technology of Intelligent Railway Logistics Park Information Management Platform. *Railway Transport and Economy*, **42**, 14-20.

[11] Chen, Q. and Ji, R.T. (2018) A Design of Intelligent Service System for Railway Cold Chain Logistics of China Railway Taiyuan Group. *Railway Transport and Economy*, **40**, 64-69.

[12] Lin, C.Z. (2021) Discussion of Intelligent Design of Railway Cold Chain Logistics. *Railway Transport and Economy*, **43**, 55-59+64.

[13] Chen, Y.H. (2020) Intelligent Algorithms for Cold Chain Logistics Distribution Optimization Based on Big Data Cloud Computing Analysis. *Journal of Cloud Computing*, **9**, Article No. 37. https://doi.org/10.1186/s13677-020-00174-x

[14] Swamidass, P.M. (2000) Seven "Rights" of Logistics, Encyclopedia of Production and Manufacturing Management. Springer, Boston, 684.

[15] Lin, N. (2019) Development-Strategy Selection of Intelligent Logistics Mode from the Perspective of Supply Chain. *Journal of Technical Economics & Management*, No. 12, 60-64.

[16] Yang, Z.Z., Sun, Y. and Lee, T.P. (2020) Impact of the Development of the China-Europe Railway Express—A Case on the Chongqing International Logistics Center. *Transportation Research Part A*: *Policy and Practice*, **136**, 244-261. https://doi.org/10.1016/j.tra.2020.03.022

[17] Balog, M., Sokhatska, H. and Iakovets, A. (2019) Intelligent Systems in the Railway Freight Management. *International Scientific-Technical Conference MANUFACTURING*, Poznan, 19-22 May 2019, 390-405. https://doi.org/10.1007/978-3-030-18715-6_33

[18] Lu, Y., Xu, X.F., Yin, C.Z. and Zhan, Y. (2021) Network Optimization of Railway Cold Chain Logistics Based on Freight Subsidy. *Transportation Research Record*, **2675**, 590-603. https://doi.org/10.1177/03611981211011998

[19] Chang S., Hu B., Wang T.T. and Ding, L. (2020) Coordination of Make-to-Order Supply Chain with Volume Flexibility. *Journal of Systems Engineering*, **35**, 610-622.

[20] Ai, B., Molisch, A.F., Rupp M. and Zhong, Z.-D. (2020) 5G Key Technologies for

Smart Railways. *Proceedings of the IEEE*, **108**, 856-893. https://doi.org/10.1109/JPROC.2020.2988595

[21] Mašek, J., Kolarovszki, P. and Čamaj, J. (2016) Application of RFID Technology in Railway Transport Services and Logistics Chains. *Procedia Engineering*, **134**, 231-236. https://doi.org/10.1016/j.proeng.2016.01.064

[22] Sun, X., Gao, L. and Liang, Y. (2019) Research on Big Data Acquisition and Application of Cold Chain Logistics Based on Artificial Intelligence and Energy Internet of Things. *IOP Conference Series*: *Earth and Environmental Science*, **252**, Article ID: 052052. https://doi.org/10.1088/1755-1315/252/5/052052

[23] Meng, D.B., Sun, M. and Zhang, Y.S. (2020) A Discussion on the Development Strategy of Railway Cold-Chain Transportation. *Railway Transport and Economy*, **42**, 44-47+53.

[24] China Railway (2018) The 13th Five-Year Development Plan for the Layout of Railway Cold Chain Logistics Network. http://www.china-railway.com.cn/gsjs/gszl/201812/t20181217_91341.html

[25] Li, J. (2019) A Research on Intelligent Logistics Mode Reconstruction Based on Big Data Cloud Computing. *China Business and Market*, **33**, 20-29.

[26] Kang, D., Guo, M. and Chen, G. (2021) Literature Review of Cold Chain Logistics Research in China Based on CiteSpace. *The International Conference on Artificial Intelligence and Logistics Engineering*, Vol. 82, Kiev, 22-24 January 2021, 307-316. https://doi.org/10.1007/978-3-030-80475-6_30