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A Study on the Governance of Hazardous Materials Transportation Platforms in a Data-Driven Context - Build on the success of Full Truck Alliance

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Abstract: The hazardous chemical transportation industry is witnessing unprecedented changes, especially with the rapid development of digital technology driven by big data, artificial intelligence and other technologies. In this context, there is an urgent need for the industry to establish an efficient, safe and reliable platform for the transportation of hazardous chemicals. Taking the hazardous chemical transportation platform as the research object, this study explores how hazardous chemical transportation can achieve safety and efficiency improvement in a data-driven context through platform governance. By analyzing the operation mode of existing dangerous goods transportation platforms and combining the latest data governance technologies, a set of systematic governance strategies is proposed to provide a theoretical basis and practical reference for the digital transformation of related enterprises.

Keywords: Data-driven; Hazardous Materials Transportation; Platform Governance; Safety Management

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1. Introduction

1.1 Background of the Study

In the tide of global digital transformation, the rapid development of information technology is profoundly changing the mode of operation and management of various industries. The field of hazardous chemical transportation has always been the core concern of safety management because it involves high-risk types of goods. However, the traditional mode of governance in the face of the complexity of the modern logistics environment, gradually revealed a number of shortcomings, such as real-time data collection capacity is weak, risk warning lag and other issues. The recent media exposure of a serious food safety incident in which a hazardous material transporter mixed kerosene with cooking oil not only exposed the problem of inadequate supervision, but also highlighted the industry's urgent need for transformation and upgrading.

The rapid development of emerging technologies, such as big data artificial intelligence, has made the governance of the hazardous materials transportation platform a key issue that needs to be urgently resolved, and how to effectively use these technologies to make the hazardous materials transportation platform to achieve data-driven high efficiency and safety has

become an inevitable trend of the industry's development. Against this background, it is already a necessity to establish a platform for promoting the safe and efficient development of hazardous materials transportation.

1.2 Research Questions

The hazardous materials transportation industry faces a series of complex challenges in safety management and operations in the current digital context. These challenges are difficult to cope with the traditional governance model, and it has become imperative to explore new solutions. This research revolves around the core issue of how to effectively apply big data and artificial intelligence technologies to improve safety and management efficiency in the hazardous chemical transportation process. What are the shortcomings of the existing governance model for hazardous materials transportation platforms, and how can these shortcomings be remedied through data-driven governance? How can a data-driven hazardous materials transportation platform build a sustainable governance structure? The solution to these questions will have a theoretical basis for digital transformation and safety management in the hazardous materials transportation industry, and give guidance in practice.

1.3 Objectives of the Study

The main objective of this research is to propose a set of systematic governance strategies to promote the safety and management efficiency of hazardous materials transportation by analyzing the operation mode and governance status quo of existing hazardous materials transportation platforms and combining the data-driven governance concept. Specifically, the research objectives include: assessment of the governance status quo of existing dangerous goods transportation platforms and the challenges they face, identification of major risk points and management deficiencies, etc.; study of the application scenarios of big data and AI technologies in dangerous goods transportation, exploring their roles and effects, and facilitating the upgrading of the platform's governance; establishment of a framework for governance of dangerous goods transportation platforms based on data-driven and feasible operational Guidelines and proposed implementation paths; theoretical basis and practical reference for digital transformation of relevant enterprises, and validation of the proposed governance strategies through case studies.

1.4 Significance of the Study

At the theoretical level, this paper fills the research gap in this field and expands the academic research perspective of digital governance by systematically studying the governance of hazardous materials transportation platforms in a data-driven context. At the practical level, the research results in this paper will provide actionable management strategies for hazardous chemical transportation enterprises, helping them to realize efficient operation and safety of the platform through data-driven, thus enhancing overall market competitiveness. These results not only have important academic value, but also have significant practical application value.

2. Review of Literature Related to the Governance of Data-driven Hazardous Materials Transportation Platforms

2.1 Data-driven Governance

Data-driven governance plays a crucial role in the Hazardous Materials Transportation Platform, where the combination of big

data, artificial intelligence, and digital technologies enables decision makers to access accurate data in real time to support policy formulation and optimize governance processes. This data-based decision-making model improves the science and implementation of policies, especially when dealing with complex transportation safety issues, and data-driven policy development and intelligent governance provide a more reliable support base for platforms (Ban et al., 2020) [3].Cole (2020) [4] showed that data-driven material discovery processes can, through the integration of chemical data and high-performance computation significantly accelerate the development of new materials and provide important technical support for hazardous chemicals management. Meanwhile, the application of AI in green manufacturing shows great potential in industrial processes, especially in risk management in hazardous chemicals handling (Mao et al., 2019) [8]. And in the field of knowledge management, methods based on knowledge mapping can effectively solve the problem of information dispersion in the management of hazardous chemicals and provide more comprehensive decision support for managers (Zheng et al., 2020) [10].

2.2 Intelligent Management

In the management of hazardous chemical transportation, intelligent management system realizes the automated management and optimization of the transportation process through the application of AI, IoT, and machine learning technologies, which improves the efficiency and safety of logistics.Fang et al. (2020) [5] argued that the AI-assisted safety system designed and developed can significantly improve the safety of hazardous chemical storage facilities and reduce the incidence of accidents. Intelligent environmental monitoring systems are also widely used in the chemical production process to ensure environmental safety in the production process by monitoring toxic emissions in real time through big data technology (Ji, 2022) [6].Ahmed et al. (2023) [1] demonstrated how a data-driven approach can improve the efficiency and sustainability of equipment management in predictive maintenance planning in smart manufacturing. In the application of smart safety systems, the risk of accidents in the chemical and petroleum industries can be effectively reduced through the integration of IoT technologies (Ansaldi & Bragatto, 2019) [2].

2.3 Hazardous Materials Transportation

Hazardous chemical transportation must rely on advanced management systems and technical means to ensure safe transportation, which is a process involving high risk. A modern hazardous chemical transportation management system integrating GIS, GPS and real-time data monitoring technology can realize the whole process of risk assessment and emergency response, thus effectively reducing the incidence of transportation accidents and ensuring the safety of people and the environment (Yang et al., 2019) [10]. When managing the transportation of hazardous chemicals, the intelligent management system improves logistics efficiency and safety by optimizing algorithms through real-time data analysis (Zhou et al., 2021) [12]. In addition, the introduction of intelligent emergency command strategy provides an important technical support for urban hazardous materials disaster management to strengthen the emergency response capacity during hazardous materials transportation (Lyu et al., 2023) [7].

2.4 International Studies and Case Applications

Globally, there are more and more cases of application of data-driven governance models and intelligent management systems in the transportation of hazardous chemicals, especially in international transportation and supply chain management, and the successful experiences of different countries provide references for the development of global standards. For example, a data-driven approach can effectively assess the risk of hazardous substances in construction stockpiles and provide a scientific

management basis for the transportation of hazardous chemicals in the global supply chain (Wu et al., 2021) [9]. International case studies on smart logistics show that intelligent management systems can significantly improve operational efficiency and service quality in complex international supply chains (Ahmed et al., 2023) [1]. The knowledge graph-based hazardous chemicals management approach provides important technical support for the development and implementation of international hazardous chemicals transportation regulations (Zheng et al., 2020) [10].

3. Governance Strategies for Dangerous Goods Transportation Platforms

3.1 Data Sources and Collection

First, the actual data sources need to be clarified. Real-time monitoring data of transportation vehicles, historical transportation records, accident reports, market demand data, etc., the data of the hazardous chemical transportation platform can come from multiple channels. These data are collected in real time by technical means, such as IoT devices, GPS tracking systems, platform management systems, etc. In addition, in order to ensure the comprehensiveness and representativeness of the data, the internal operation data of the enterprise and the external environment data (e.g. weather, road conditions, etc.) should also be included in the scope of information collection.

3.2 Data Analysis Methods

When the data collection is finished, then proceed to analyze the data. This paper suggests the following analysis methods: (1) Descriptive statistical analysis: through descriptive statistical methods (such as mean, variance, frequency distribution, etc.), the key indicators in the transportation process are initially processed and summarized, so as to reveal the basic characteristics of the data, and the data collected are initially processed. (2) Regression analysis and modeling. The key factors affecting the safety and efficiency of hazardous chemical transportation are analyzed by establishing regression models or other statistical models based on historical data. The impact of different factors on transportation results can be quantified through model analysis, thus providing a basis for quantification and making the governance strategy more optimized. (3) Forecasting by time-series analysis: For time-series information, the forecasting of future transportation demand and potential risks can be carried out by using the method of time-series analysis. By analyzing the historical trend, the future transportation pattern is predicted and adjusted and optimized in advance. (4) Case study validation: typical cases of transportation are selected, and on the basis of the analysis results, an in-depth analysis is conducted to see whether the proposed governance strategies are effective in actual application. Through the case study, the advantages and shortcomings of the strategy in actual operation are found, and the model and strategy are further optimized.

3.3 Data Validation and Discussion

Once the analysis of the information is completed, it is necessary to validate and question the proposed governance strategy. For the strengths and room for improvement of the new strategy, it is recommended that the analysis results be explored in comparison with the existing governance model. The research results will be made more credible through the support of empirical research and significantly enhance the practical guidance value of the thesis.

3.4 Experimental Design and Empirical Studies

Experimental design and empirical studies are recommended where available. For example, data-driven governance strategies

can be implemented on a small scale on a pilot basis, and their effectiveness can be verified through quantitative analysis. Experimental studies can provide both direct evidence of the effectiveness of the strategy and informative information for future full-scale roll-out.

By adding the empirical research part, the research method of this paper will be more complete, which will help to improve the reliability and application value of the research results. At the same time, through the support of actual data, the proposed governance strategies will be more instructive in actual operation.

4 Full Truck Alliance Introduction and Implications

4.1 Introduction to Full Truck Alliance

Full Truck Alliance, founded in 2017, was formed by the merger of two major trucking platforms, Yun Man Man and Truck Help. Full Truck Alliance is the largest digital freight transportation platform in China. As China's largest digital trucking platform, Full Truck Alliance provides online matching services between shippers and truck drivers through its mobile app, greatly optimizing China's highly fragmented logistics market. Currently, Full Truck Alliance has 2.65 million monthly active shippers and 3.98 million active drivers in the last twelve months of fulfillment. The financial report shows that Full Truck Alliance's revenue for FY2023 is 8.436 billion yuan.

Full Truck Alliance's business models include freight brokerage services, trade services, value-added services, membership services, etc. Full Truck Alliance has been able to scale up and monetize its platform while continuously optimizing its profitability through a dual-end matching (shipper and driver) model. In recent years, Full Truck Alliance has extended its value-added services to finance, energy, and insurance, as well as truck sales, in addition to improving transportation efficiency through increased digital penetration and reduced empty load rates.

In addition, Full Truck Alliance has partnered with Gaw Capital Partners to establish an intelligent logistics property association platform to further promote the intelligent and efficient development of the logistics industry. This platform utilizes big data and artificial intelligence algorithms to enable the entire industry to achieve intelligent management of logistics services more efficiently and intelligently.

4.2 Implications for Learning

As a leading digital freight transportation platform in China, Full Truck Alliance's successful experience provides an important reference for the governance of dangerous goods transportation platforms, and Full Truck Alliance has demonstrated excellent management and operation capabilities in the competition in the digital era. Dangerous chemical transportation platforms can learn from the following aspects of experience, through the in-depth analysis of Full Truck Alliance's development path and management mode, to achieve more efficient, safer and smarter governance.

4.2.1 Digital transformation and application of Dual-ended matching models

Through the integration of decentralized freight market resources, Full Truck Alliance has successfully established a dual-end matching business model for efficiently connecting shippers and drivers. This model improves the operational efficiency of the platform while also significantly reducing the empty load rate in the freight market and improving the overall transportation efficiency. Transportation safety and efficiency are particularly important in the field of hazardous chemical transportation. Therefore, hazardous materials transportation platforms can learn from Full Truck Alliance's double-end matching model, which

efficiently matches hazardous materials shippers with eligible professional drivers through digital technology, thus ensuring the safety and compliance of the transportation process.

In actual use, the hazardous chemical transportation platform uses big data analysis to identify and evaluate the ability and reputation of various transportation resources, so as to provide the best matching program for cargo owners according to their requirements, improve transportation efficiency as a whole, reduce potential safety hazards, and make the whole process of hazardous chemical transportation well known to ensure that nothing is lost. Through the use of double-end matching mode, the platform makes effective use of all kinds of transportation resources, so that the transportation cost can be further controlled, thus providing more competitive services for the owners, and at the same time, also laying a solid foundation for the platform's own development.

4.2.2 Data-driven intelligent management

Full Truck Alliance has a very significant advantage in the application of big data and artificial intelligence technology, and is able to analyze a large amount of transportation data in real time to optimize logistics routes and improve transportation efficiency, as well as the realization of intelligent decision-making on the platform, which provides valuable reference in the transportation of hazardous materials, and therefore also contributes to the development of the platform for the transportation of hazardous materials.

5. Contribution

Hazardous chemical transportation, real-time data collection and analysis is of great significance, to ensure transport safety plays a pivotal role. The application of Internet of Things (IoT) technology to hazardous materials transportation vehicles enables the platform to have real-time monitoring capabilities for vehicle driving conditions; then use big data analysis and artificial intelligence algorithms to predict potentially hazardous situations and issue warning signals in advance to avoid accidents; and Full Truck Alliance also uses big data technology to optimize the transportation routes to reduce the rate of unloaded vehicles. The Full Truck Alliance also uses big data technology to optimize transportation routes and reduce empty load rates, as well as to reduce uncertainty and risk in the transportation process by collecting and analyzing data on hazardous materials transportation using these methods. Through the use of big data technology, the transportation of hazardous materials has a higher level of safety.

Dangerous chemical transportation platforms can learn from the successful experience of Full Truck Alliance to prevent safety and compliance problems similar to those that occur in the process of mixing kerosene and cooking oil, so as to ensure the safety and compliance of the transportation process. Through the introduction of advanced information technology and scientific transportation management system, the hazardous materials transportation platform can keep pace with the existing logistics industry and make greater breakthroughs in the field of safe transportation.

(1) Real-time data acquisition and monitoring

The root cause of the incident of mixing kerosene and cooking oil is the problem of asymmetric information due to ineffective supervision. In order to prevent the occurrence of such incidents, the Hazardous Chemical Transportation Management Platform will rely on real-time data collection and monitoring system for effective supervision, to ensure that in all aspects of transportation can be done in accordance with the laws and regulations in place. At the same time the use of Internet of Things

technology in the transportation vehicles and storage devices installed on the corresponding equipment to obtain key information in a timely manner, such as the type of goods vehicle conditions and environmental conditions and other key data can also be traced once the monitoring of the transportation process of a certain part of any abnormalities, such as oil products do not comply with the record of the cargo information will be immediately issued an alarm and take appropriate measures to prevent the occurrence of such non-compliance with the cargo transportation. The monitoring of key data is also done to monitor any irregularities in the transportation process.

Data collection and monitoring, including vehicle operation status, are not limited to the package labeling and handling of goods, but refer to the entire monitoring of the whole process. For example, the use of image recognition technology and artificial intelligence algorithms to automatically identify the type of goods and packaging identification, so that the platform has a clear idea of whether the goods comply with the relevant standards and regulations on the transportation of hazardous chemicals, so as to eliminate the phenomenon of mixing of kerosene and cooking oil and other goods of different natures, and to avoid the emergence of food safety incidents. This kind of refined monitoring means has played an effective role in promoting the protection of transportation safety.

(2) Big data analysis and risk prediction

Intelligent data-based management systems are not limited to real-time monitoring, but more often use big data analytics in order to predict and prevent potential risks, and Full Truck Alliance's practice of optimizing logistics routes and management processes to reduce transportation risks based on analysis of large amounts of historical transportation data is also worth learning from and applying to the governance of hazardous materials transportation platforms to Raise awareness of safety precautions. In the case of the mixing of kerosene and cooking oil, if the potential dangers of some of the transportation routes or nodes can be identified in advance, the transportation platform will be able to take measures to prevent them in advance. Specifically, the platform will be able to comprehensively analyze the various types of goods on the transportation route and related historical records, etc., so as to identify some high-risk areas or cargo transportation routes, and accordingly make corresponding adjustments to the transportation plan to avoid possible safety hazards. Moreover, further analysis of big data can also help the transportation platform to establish a more complete risk assessment model, which can make corresponding adjustments to the risk level and response strategy for different transportation conditions, thus further guaranteeing the transportation safety.

(3) Intelligent Early Warning System and Emergency Response

An intelligent early warning system is indispensable for similar incidents that occur during the transportation of kerosene mixed with cooking oil. Based on real-time data analysis and machine learning algorithms, the platform monitors and evaluates abnormalities in the transportation process in real time and provides early warning of possible irregularities and notifies the relevant supervisory personnel to carry out inspections and interventions in a timely manner, so as to prevent problems before they occur. In case of any inconsistency with cargo information or actual transportation conditions, the early warning system will be automatically triggered and corresponding dispositions and notifications will be made.

Emergency response mechanism is also one of the important contents of intelligent management, after the problem occurs, the intelligent platform should have the ability to respond quickly and mobilize all kinds of resources to deal with it. The data-driven emergency plan management system helps the platform to allocate and dispatch emergency resources most appropriately according to the type of accident, location and severity of the accident and other factors, so as to make the problem solved most quickly and effectively, such as the fire department dealing with fire incidents in time, emergency medical service dealing with

emergencies and so on. For example, the fire brigade can handle fire incidents in a timely manner, and emergency medical services can respond to emergencies.

(4) Full traceability and compliance management

Intelligent management driven by data can also enable the transportation of hazardous chemicals to meet the requirements of full traceability, which is mainly realized through the use of a number of technical means, including blockchain technology. The platform will record all the data information of each batch of hazardous chemicals from departure to arrival, including the determination of the type of goods, the transportation route and the driver's information, as well as the checking situation in the middle of the journey and a series of data information, and the whole process of traceability system can not only improve the transparency of the transportation process, but also provide reliable evidence for the responsibility of the investigation after the fact, so as to avoid similar incidents of mixing of kerosene and cooking oil from occurring again.

At the same time, data analysis technology is used to carry out compliance checks on all types of transportation behaviors, and transportation behaviors that meet the requirements of the relevant regulations and standards are operated to a limited extent, thus reducing errors and omissions in human operations and maximizing the safety and legitimacy of the transportation of hazardous chemicals. Automated means of compliance checking are introduced along with real-time monitoring of data.

4.2.3 Expansion of value-added services and improvement of user stickiness

By providing diversified value-added services, such as the sale of truck insurance in the financial aspect, Full Truck Alliance not only opens up a new source of income for the platform but also enhances user adhesion, which is a useful reference for the platform of hazardous chemical transportation. Since the transportation of dangerous goods has the special transportation needs of high risk and high requirements, the platform can meet the different needs of users with customized value-added services, thus enhancing the adhesion of users to the platform and the competitiveness of the platform, and at the same time, improving the loyalty of users to the platform, which can be said to be a multi-purpose. Therefore, whether it is a platform for the transportation of hazardous chemicals or other types of platforms, in the process of development, we can learn more from Full Truck Alliance's experience.

The platform can cooperate with insurance companies to provide transportation companies with special insurance solutions for the transportation of hazardous chemicals, so as to minimize the risks in the transportation process; at the same time, the platform can also provide safety training services for users, so that drivers and management personnel have a higher awareness of safety precautions and operational skills, and these value-added services can not only bring real benefits to users, but also further enhance the platform's brand image. These value-added services can not only bring real benefits to users, but also further enhance the brand image of the platform, thus bringing real benefits to more users; at the same time, these value-added services can also bring more customers to the platform, so that the platform can be further developed and expanded; therefore, it is crucial for the platform to carry out the corresponding value-added services, which not only bring real benefits to itself.

In addition, the hazardous materials transportation platform can also draw on Full Truck Alliance's experience in financial services to provide flexible payment and financing solutions for small and medium-sized transportation enterprises, so as to help them solve the problem of capital turnover and improve the efficiency of their operations, thereby attracting more small and medium-sized enterprise customers and enhancing the platform's competitive advantage in the market, which is conducive to the platform's sustainable development.

4.2.4 Cross-border cooperation and ecosystem building

Full Truck Alliance has successfully established a wide-ranging logistics ecosystem through cross-border cooperation with various partners, bringing new ideas to the governance of the hazardous chemicals transportation platform. As the transportation of hazardous chemicals involves many links and fields, cross-border cooperation enables the platform to integrate various types of resources so as to build an all-round service network to cover all links and fields from transportation to storage to risk management, and to provide services for customers from various aspects.

Hazardous chemical transportation platform can establish strategic partnership with intelligent logistics facilities providers, financial institutions, insurance companies, etc., to jointly develop intelligent and all-round transportation solutions. By establishing strategic partnership with intelligent logistics facilities providers, such cooperation can not only enhance the service capability of the platform, but also realize win-win situation between the platform and partners through resource sharing and complementary advantages. The situation.

The platform also promotes industry standardization and regulation, and cooperates in the establishment of a standardized hazardous materials transportation management system. For example, Full Truck Alliance promotes the same applicable digital freight industry standardization in the dangerous goods transportation industry through cooperation with government departments and industry associations. The platform realizes the improvement of the industry's overall safety level and operational efficiency through the establishment of standardized management processes and operational norms.

4.2.5 Innovation and sustainability of profit models

Full Truck Alliance is constantly innovating its profit model and has improved its scale growth and profitability; similarly, as a hazardous materials transportation service platform, it is able to develop diversified development paths through innovative profit models, thus ensuring the platform's sustainable and steady development.

In the field of hazardous chemical transportation, the platform can achieve revenue growth by charging service fees, value-added service fees and partner sharing. On the basis of providing basic transportation services, the platform can choose to expand and add value-added services such as insurance, finance, logistics consulting, etc., to further expand the source of income. Providing customized data analysis reports and consulting services to relevant industries through data analysis and big data services is also a potential new profit point for the platform.

Meanwhile, after the platform continuously improves the service quality and user experience, the stickiness and loyalty of users are greatly enhanced, which ensures the long-term development of the platform. Full Truck Alliance has successfully increased the activity of users and the market share of the platform by continuously optimizing the user experience and the service quality, therefore, the hazardous chemical transportation platform can also learn from this approach, and achieve sustainable development by continuously innovating and optimizing its services. Therefore, dangerous goods transportation platforms can also learn from this approach and achieve sustainable development through continuous innovation and optimization of services. For example, they can learn from Full Truck Alliance's approach and make their own contribution to promoting the sustainable development of the dangerous goods transportation industry.

6. Conclusion

Starting from a data-driven perspective and based on Full Truck Alliance's successful experience in the field of hazardous

materials transportation, this paper conducts an in-depth research on the intelligent governance strategy of hazardous materials transportation platforms, and proposes a set of systematic governance solutions to ensure that the hazardous materials transportation platforms are highly efficient in terms of safety and management, and to improve market competitiveness. The relevant research results show that the data-driven governance model can play an effective role in promoting safety and efficiency in the process of dangerous goods transportation, and improve and precision in resource allocation and risk management with the help of big data and artificial intelligence technology.

Full Truck Alliance's digital transformation experience has important implications for the governance strategy for hazardous materials transportation platforms proposed in this paper. The analysis of Full Truck Alliance's specific practices in intelligent scheduling risk prediction and value-added service expansion proposes a governance strategy applicable to hazardous chemical transportation platforms for this paper. Full Truck Alliance successfully integrates technology and management to make its logistics platform stand out in the fierce market competition, and this experience is also applicable to the hazardous chemical transportation industry, especially to improve the platform's intelligence level and market adaptability. Therefore, this paper proposes a governance strategy based on the above practices for the reference of the majority of dangerous goods transportation platforms.

Overall, this thesis gives theoretical basis and practical oriented guidelines for the digital transformation and intelligent governance of the hazardous materials transportation platform, and also points out the future development direction of the industry, which can be optimized and improved by combining the data-driven technology and the successful experience of Full Truck Alliance; through the introduction of informatization means and the implementation of digital governance.

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