

Original Paper

doi [10.15826/recon.2023.9.2.008](https://doi.org/10.15826/recon.2023.9.2.008)

UDC 338.2

JEL L62, M15, Q56



Role of digitalization of logistics outsourcing in sustainable development of automotive industry in China

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Southern Federal University, Rostov-on-Don, Russian Federation; ✉ chernova.olga71@yandex.ru**ABSTRACT**

Relevance. Digital technologies can bring regional logistics outsourcing in the automotive industry to a new level of performance. However, the digitalization of logistics outsourcing and its role in improving the sustainability of the automotive industry are poorly understood.

Research objective. To develop the conceptual framework of the digital ecosystem of regional logistics outsourcing in the automotive industry. The object of the study is the automotive industry in China.

Data and methods. Prospects for the digitalization of regional logistics outsourcing of the automotive industry and its impact on the sustainability of the industry are considered in terms of the economics of transaction costs and a resource-based approach. The data sources involved the national policy documents reflecting the strategic directions of digital development of China, statistical data provided by the National Bureau of Statistics of China, as well as research papers presented in the Scopus database.

Results. The authors analyzed the trends of digital transformations in the geographic clusters of production of the automotive industry in China. The digitalization of regional logistics outsourcing was determined to influence the sustainability of the automotive industry development in the context of its economic, social, environmental and technological components. The logistics ecosystem model developed by Capgemini was supplemented by the conceptual framework of the digital logistics outsourcing ecosystem for the Chinese automotive industry. The key components of this framework were determined.

Conclusions. It can be concluded that digitalization of regional logistics outsourcing will contribute to increasing the sustainability of the automotive industry. However, this requires the formation of a digital landscape of logistics outsourcing, which involves changes in the entire supply chain management system. The results of the study can be used to improve the efficiency of supply chain management in the automotive industry.

KEYWORDS

automotive industry, outsourcing, regional logistics, supply chain management, sustainable development, digitalization, geographic clusters of production, China.

FOR CITATION

Chernova, O. A., Liu, L., & Wang, X. (2023). Role of digitalization of logistics outsourcing in sustainable development of automotive industry in China. *R-Economy*, 9(2), 123–139. doi: 10.15826/recon.2023.9.2.008

Роль цифровизации логистического аутсорсинга в устойчивом развитии автомобильной промышленности Китая

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Актуальность. Цифровые технологии позволяют вывести региональный логистический аутсорсинг в автомобильной промышленности на новый уровень результативности. Однако вопросы цифровизации логистического аутсорсинга и его роль в повышении устойчивости развития автомобильной промышленности являются малоизученными.

Цель и объект исследования состоит в разработке концептуальной структуры цифровой экосистемы регионального логистического аутсорсинга в автомобильной промышленности. Объектом исследования является автомобильная промышленность Китая.

КЛЮЧЕВЫЕ СЛОВА

автомобильная промышленность, аутсорсинг, региональная логистика, управление цепочками поставок, устойчивое развитие, цифровизация, географические центры производства, Китай

Данные и методы. Перспективы цифровизации регионального логистического аутсорсинга автомобильной промышленности и исследование его влияния на устойчивость развития отрасли рассмотрены через призму экономики транзакционных издержек и ресурсоориентированного подхода. Источниками данных являлись материалы национальных программных документов, отражающих стратегические направления цифрового развития Китая, статистические данные National Bureau of Statistics of China, а также научные статьи, представленные в базе Scopus.

Результаты. Проанализированы тенденции цифровых трансформаций в географических центрах производства автомобильной промышленности Китая. Определено влияние цифровизации регионального логистического аутсорсинга на устойчивость развития автомобильной промышленности в разрезе экономической, социальной, экологической и технологической составляющих. В развитие модели логистической экосистемы, разработанной компанией Cargemini, сформирована концептуальная структура цифровой экосистемы логистического аутсорсинга для автомобильной промышленности Китая и выделены ее ключевые компоненты.

Выводы. Сделан вывод о том, что цифровизация регионального логистического аутсорсинга будет способствовать повышению устойчивости развития автомобильной промышленности. Однако для этого необходимо формирование цифрового ландшафта логистического аутсорсинга, предполагающего изменения во всей системе управления цепочками поставок. Результаты исследования могут быть использованы для решения задач повышения эффективности управления цепочками поставок в автомобильной промышленности.

ДЛЯ ЦИТИРОВАНИЯ

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物流外包数字化对中国汽车行业可持续发展的作用

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摘要

现实性：数字技术可以将汽车行业的区域物流外包提升到新的效率水平。然而，人们对物流外包数字化问题及其在提高汽车行业发展可持续性方面的作用却知之甚少。

研究目标与对象：研究旨在开发汽车行业区域物流外包数字生态系统的概念框架。文章研究对象是中国的汽车工业。

数据与方法：文章通过交易成本经济学和资源导向的视角，考察了区域汽车物流外包的数字化前景以及研究其对行业可持续发展的影响。数据来源包括中国数字化发展战略的国家政策文件材料、中国国家统计局的统计数据，以及Scopus数据库的研究文章。

研究结果：文章分析了中国汽车制造业地理中心的数字化转型趋势。确定了区域物流外包数字化对汽车行业在经济、社会、环境和技术方面的可持续影响。在凯捷公司物流生态系统模型的基础上，文章建立了中国汽车行业数字化物流外包生态系统的概念框架，并强调了其关键组成部分。

研究结论：区域物流外包数字化将有助于增强汽车行业发展的可持续性。然而这需要形成物流外包数字化格局，这涉及整个供应链管理体系的变革。该研究可用于应对改善汽车行业供应链管理的挑战。

关键词

关键词：汽车工业、外包、区域物流、供应链管理、可持续发展、数字化、生产地理中心、中国。

供引用

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Introduction

Logistics is essential in automotive production due to the large volume and variety of parts to be delivered within a certain time frame and in a strictly prescribed sequence. The Fourth Industrial Revolution (Industry 4.0) and digital technologies are significantly changing the principles and approaches to logistics management

within the emerging “supply chain as a service” paradigm (Ivanov et al., 2022). The automotive industry is now evolving into a complex digital ecosystem with new players and partners integrated into supply chains (Fabbe-Costes, Lechaptois, 2022). At the same time, regional logistics is becoming increasingly important. In China, this became most relevant in the COV-

ID-19 pandemic with all the restrictions imposed, when, in order to effectively organize material flows, automakers actively developed regional logistics outsourcing and integrated it with national and international logistics systems based on digital solutions. Therefore, many Chinese automobile companies are currently undergoing a fundamental paradigm shift, transforming their capabilities in supply chains as part of the transition from an industrial society to an IT-driven society (Jehan, 2021; Holubčík et al., 2021; Reddy et al., 2021).

Digital technologies bring the automotive industry to a new level of efficiency of business processes, forming their new content and architecture (Jehan, 2021). At the same time, many automakers come to the conclusion that without the involvement of qualified personnel, it is impractical and costly to establish business processes in the logistics sector. The search for a mechanism to minimize the costs associated with various transactions of the company leads to the decision to use logistics outsourcing. The involvement of a third-party regional logistics provider for logistics management enables companies not only to reduce transportation costs, but also to optimize cargo delivery, increase its speed, and enhance logistics services (Krakovics et al., 2008). As Reeves et al. (2010) note, in order to increase the sustainability of performance, automobile companies should own those assets that create value for them and present a source of competitive advantage, while the remaining assets should be transferred. Therefore, regional logistics outsourcing has recently become the dominant strategic direction of many companies in the automotive industry.

However, the role of digitalization of logistics outsourcing in increasing the sustainability of the automotive industry is still poorly understood in the economic community. Thus, the aim of the study is to develop the conceptual framework of the digital ecosystem of regional logistics outsourcing in the automotive industry. The hypothesis of the research is the assumption that in order to increase the sustainability of the automotive industry, it is necessary to create a digital landscape of regional logistics outsourcing, which involves changes in the entire supply chain management system. The object of the study is the automotive industry in China.

Theoretical basis

The application of logistics outsourcing in the automotive industry has received much attention in the scientific community. As is known, outsourcing means the transfer of activities, which are usually carried out internally, to an external party – a specialized service provider. Logistics outsourcing serves the primary goals of providing cost leadership and competitive advantage through the harmonization of organizational and technological changes. The co-occurring resource and functional efficiency has made logistics outsourcing a powerful business trend in modern automobile companies (Tripathi, 2020).

The scientific literature provides the following reasons motivating automobile companies to outsource their logistics services:

- reducing costs and improving the quality of logistics services and interactions (Fadile et al., 2018, Mathauer, Hofmann, 2019);
- concentrating on key competencies and avoiding those activities that do not represent competitive advantages (Kalinzi, 2016);
- increasing the level of digitalization in production through the use of the advantages of specialized knowledge and developed information systems (Gunasekaran et al., 2017; Yazdi, et al., 2018; Cichosz et al., 2020);
- improving the supply chain management (Christopher et al., 2016; Delfmann et al., 2018).

Logistics outsourcing in the automotive industry (as well as for the entire industry as a whole) is characterized by digitalization – the active introduction of digital technologies into value chains (Llopis-Albert, et al., 2021). One of the most common digital tools in modern automotive logistics is an IT platform that enables the management of resource flows in supply chains. Combining such IT platforms of individual participants in the supply chain leads to the formation of entire ecosystems – communities of “independent entities that jointly create value added” (Dmitriev, Nos, 2022).

The dominant logic of digital transformation research in logistics outsourcing is based on scientific technological and network-centric approaches (Christopher et al., 2016). Here, researchers note that the digitalization of logistics, expressed by the transition to data-driven management and the active use of digital service capabilities, can significantly reduce the cost of obtaining and processing information, as well as increase the efficiency, mobility, and competitiveness of com-

panies and industry (Llopis-Albert, et al., 2021; Birkmaier et al., 2021).

In recent years, researchers have recognized the importance of digitalization of logistics outsourcing for increasing the sustainability of the automotive industry. Most often, scholars focus on achieving environmental goals (Kristel et al., 2014; Rashid et al., 2015). They emphasize that digital technologies are crucial for the formation of environmentally friendly supply chains (Ghadge et al., 2022). Along with this, scholars study the impact of logistics outsourcing on the economic and social parameters of the sustainability of the automotive industry. For example, Rodríguez-González et al. (2022) analyze the adoption of circular economy practices in supply chains to achieve sustainable development goals. In the study of the impact of logistics outsourcing on the development of the automotive industry, scholars identify three components of sustainability: economic, environmental and social (Ghadimi et al., 2017; Luthra et al., 2017; Mani et al., 2016; Szász et al., 2021). Most studies are empirical and focus on a specific region or country. Researchers tend to consider the selection of service providers according to sustainability criteria. Although a number of researchers note that the use of Industry 4.0 technologies increases the opportunities for sustainable development of the automotive industry (Chin et al., 2015; Vanalle et al., 2017), they pay little attention to establishing a connection between digital transformations in logistics outsourcing and indicators of sustainable development of the industry. In addition, the authors of the present paper found no studies that focus on structuring a digital logistics outsourcing model for the automotive industry. This determines the relevance and significance of the study.

Methodology and data

The study seeks to identify opportunities for using digital technologies in logistics outsourcing in the automotive industry in order to increase the sustainability of its development and elaborate the conceptual framework of the digital ecosystem of regional logistics outsourcing in the automotive industry.

The study is designed in the following way. The first stage involves analyzing the digital transformation of China's automotive industry and its individual regions – the geographical clusters of automotive production. The analysis included national policy documents reflecting the strategic

directions of digital development: Made in China 2025, White Paper on the Development of China's Digital Economy, China Standards – 2035, China's 14th Five-Year Plan (2021-2025) for Digital Economy (“十四五” 数字 经济发展 规划)¹. The analysis involved the data from the China Academy of Information and Communications Technology, the National Bureau of Statistics of China, the International Monetary Fund, the International Organization of Motor Vehicle Manufacturers².

The second stage of the study focuses on examining the directions of digital development of regional logistics outsourcing in the automotive industry of China according to the principles of sustainable development. Prospects for digitalization of logistics outsourcing of the automotive industry are considered in terms of transaction cost economics and a resource-based approach (Reeves et al., 2010). When considering the impact of logistics outsourcing on the sustainability of the automotive industry, technological sustainability should be determined in addition to the traditionally identified components (environmental, social, economic sustainability) (Fig. 1).

As is known, environmental sustainability reflects the ability of the socio-economic system to protect and strengthen the processes of reproduction of natural ecosystems, which forms the material basis for development. Social sustainability implies the ability of the system to improve the living standards of the population and can be referred to as a target for its development. Economic sustainability characterizes the abili-

¹ Made in China 2025 (2022). Retrieved from: <https://chinalogist.ru/infographics/kak-kitay-budet-dobivatsya-statusa-velikoy-proizvodstvennoy-derzhavy-8684>; White Paper on the Development of China's Digital Economy (中国数字 经济发展白皮书). Beijing: China Academy of Information and Communication Technology (北京:中国信息通信研究院), 2021年4月. – 80页; “China Standards – 2035” (“中国 标准2035. Retrieved from: <https://www.china-briefing.com/news/made-in-china-2025-explained/>; China's 14th Five-Year Plan (2021-2025) for Digital Economy Development (“十四五” 数字 经济发展规划). Retrieved from: http://www.gov.cn/zhengce/content/2022-01/12/content_5667817.htm

² China Academy of Information and Communications Technology. Retrieved from: <https://academy.itu.int/itu-d/projects-activities/centres-excellence/coe-cycles/coe-cycle-2019-2022/coe/china-academy-information-and-communications-technology>; National Bureau of Statistics of China, 2022. Retrieved from: <http://www.stats.gov.cn/english/>; China's Digital Economy: Opportunities and Risks, 2019. International Monetary Fund Working Paper. International Monetary Fund. Retrieved from: <https://www.imf.org/en/Publications/WP/Issues/2019/01/17/>; China Association of Automobile Manufacturers, 2022. Retrieved from: <https://www.oica.net/category/sales-statistics/>

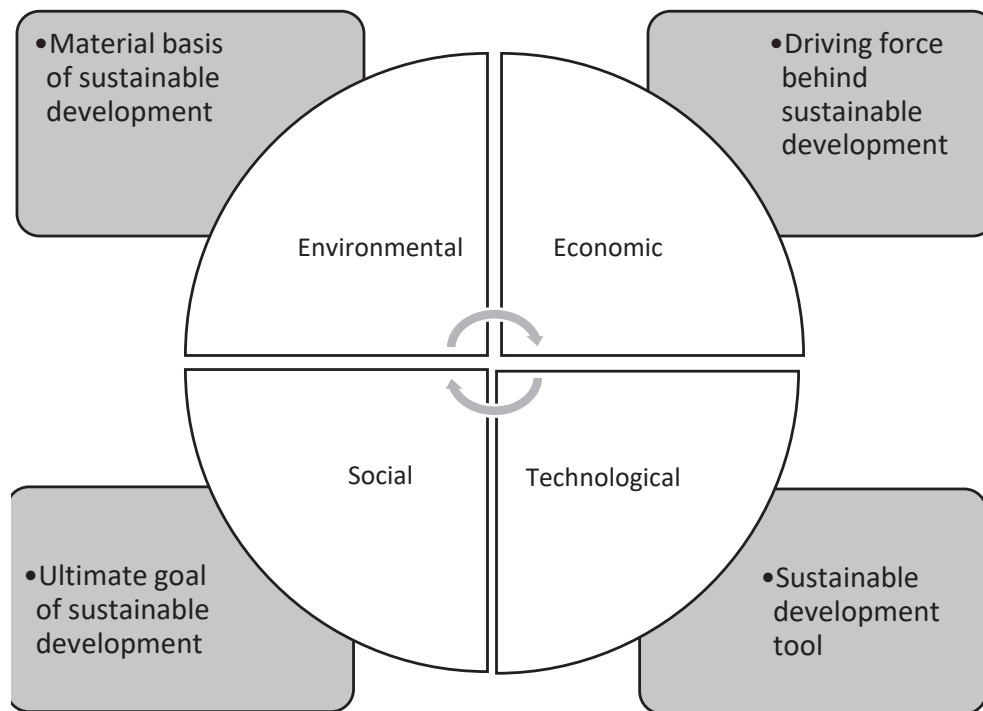


Figure 1. Components of sustainable industrial development
Source: compiled by the authors

ty of the system to withstand external influences. Technological sustainability can be defined as the ability of a system to use more advanced and efficient technologies to achieve its development goals.

Obviously, the technological component of sustainability cannot be equated with economic. If economic sustainability is inherently the driving force behind development, technological sustainability is the tool to maintain the driving force. This conclusion stems from generalization of ideas of different researchers about the technological component of sustainable development of socio-economic systems. Thus, Javaid et al. (2022) note that a large set of modern technologies allows company management to choose those that most effectively provide certain results in terms of sustainable development. At the same time, Adomako and Tran (2022) draw attention to the fact that it is the technology of resources transformation involved in the production that delivers certain sustainability parameters. Research by Zimek et al. (2022) also confirms that changing management and process technologies can help to achieve sustainable development goals. Therefore, underestimating the importance of the technological

component of sustainable development can lead to underutilization of innovative technologies in solving the tasks of “green” socio-economic development.

Thus, in order for the socio-economic system to be sustainable, it is necessary: 1) to have the appropriate resources for this; 2) to understand the goal of its development; 3) to understand what tools (technologies) can be used to achieve this goal; 4) to have motivation (incentives) to use these tools. Identifying these four components of sustainable development, we thus combine two different aspects of sustainability: from the standpoint of a systematic approach – the identification of the constituent subsystems of sustainable development (economic, social, environmental and technological); from the standpoint of a process approach – the identification of the main components of the sustainable development management process (resources, goals, tools and incentives).

When studying the effects of introducing digital technologies into the regional logistics outsourcing system for the sustainable development of the automotive industry, the authors relied on the agency cost theory in business ecosystems, the theory of dynamic capabilities and digital transformation of logistics.

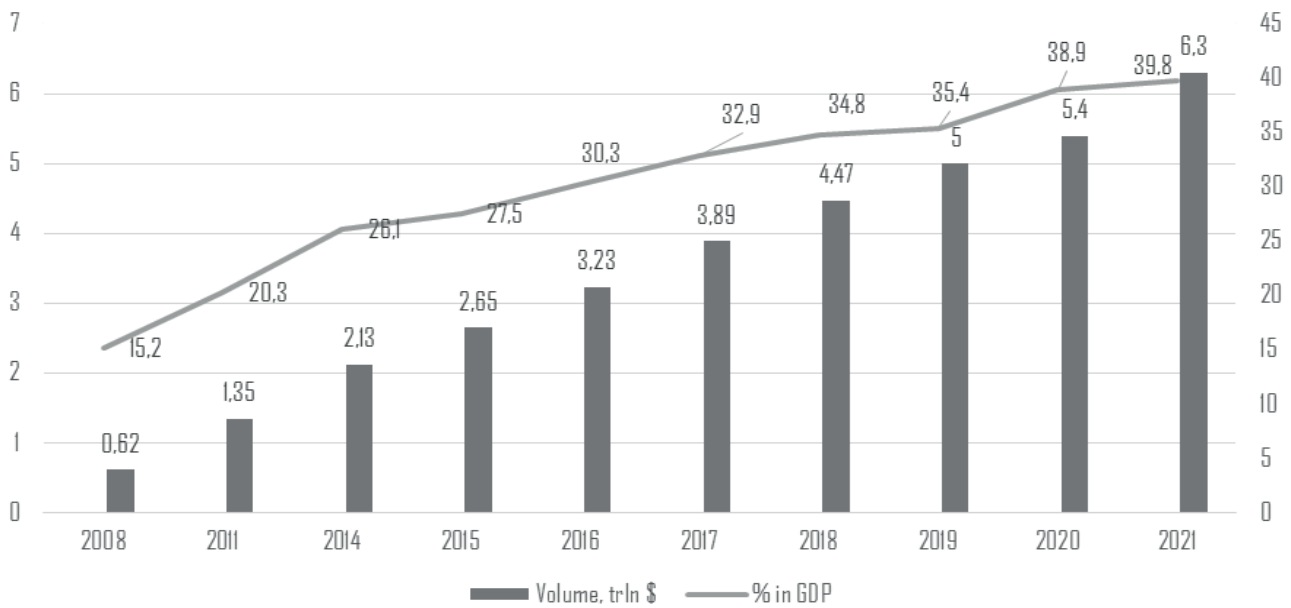


Figure 2. China's Digital Economy, 2008–2021

Source: calculated by the authors based on data from China Academy of Information and Communications Technology (CAICT, 2022) <https://academy.itu.int/itu-d/projects-activities/centres-excellence/coe-cycles/coe-cycle-2019-2022/coe/chi-na-academy-information-and-communications-technology>; National Bureau of Statistics of China (NBS), (2022) <http://www.stats.gov.cn/english/>

At the third stage of the study, the authors proposed a conceptual framework of the digital ecosystem of regional logistics outsourcing in the automotive industry and identified the requirements for it in terms of creating prerequisites for increasing the sustainability of the industry. When forming this framework, the authors based their choice on the model of the logistics ecosystem developed by Capgemini – one of the most competent companies in the world providing services in the field of management, information technology and business process support – and supplemented it with the characteristics of the main components, taking into account the specificity of the logistics of the automotive industry. This choice is driven by the fact that the Capgemini model provides proper integration of business processes of digital logistics ecosystem. However, existing scientific sources dedicated to the formation of digital supply chain ecosystems (Makarova et al., 2022; Seliverstova et al., 2022; Li et al., 2023) reflect only individual aspects of transport and logistics services rather than a full picture of components to be included in a logistics digital ecosystem.

In conclusion, the authors indicated the prospects for the formation of a digital ecosystem of regional logistics outsourcing to increase the sustainability of the automotive industry.

Results and Discussion

Digital transformations in China's automotive industry

The digital economy has become a new driving force behind China's economic growth, and its development model is an example for the whole world. China has recently unveiled a series of major projects and plans that reflect the strategic directions of digitalization, laying the foundation for the stable development of China's digital economy. In 2021, it reached 6.3 trillion dollars (Fig. 2). In Beijing and Shanghai, the added value of the digital economy is already more than 50% of GDP. This is the highest level in the country. The digital economies of Guangdong, Zhejiang, Jiangsu, and Fujian account for more than 40% of GDP.³

The digital economy is not just another stage of economic development. It is a philosophy of life, new trends and tendencies that undoubtedly affect all sectors of the economy. The digitization of industry dominates the digital economy. From 2008 to 2021, the share of digitalization of Chinese industry in GDP increased from 8.8% to 33.6%. The contribution of digitalization of industry to economic growth reached 90% (Fig. 3).

³ Statistical Report on Internet Development in China, 2022 (第50次《中国互联网络发展状况统计报告》发布, 2022)// Retrieved from: http://www.gov.cn/xinwen/2022-09/01/content_5707695.htm

The indicators of digitalization of China’s industry by region (province) are presented in Table 1. It should be noted that geographically, the

production clusters of the automotive industry are located almost in all regions of China.

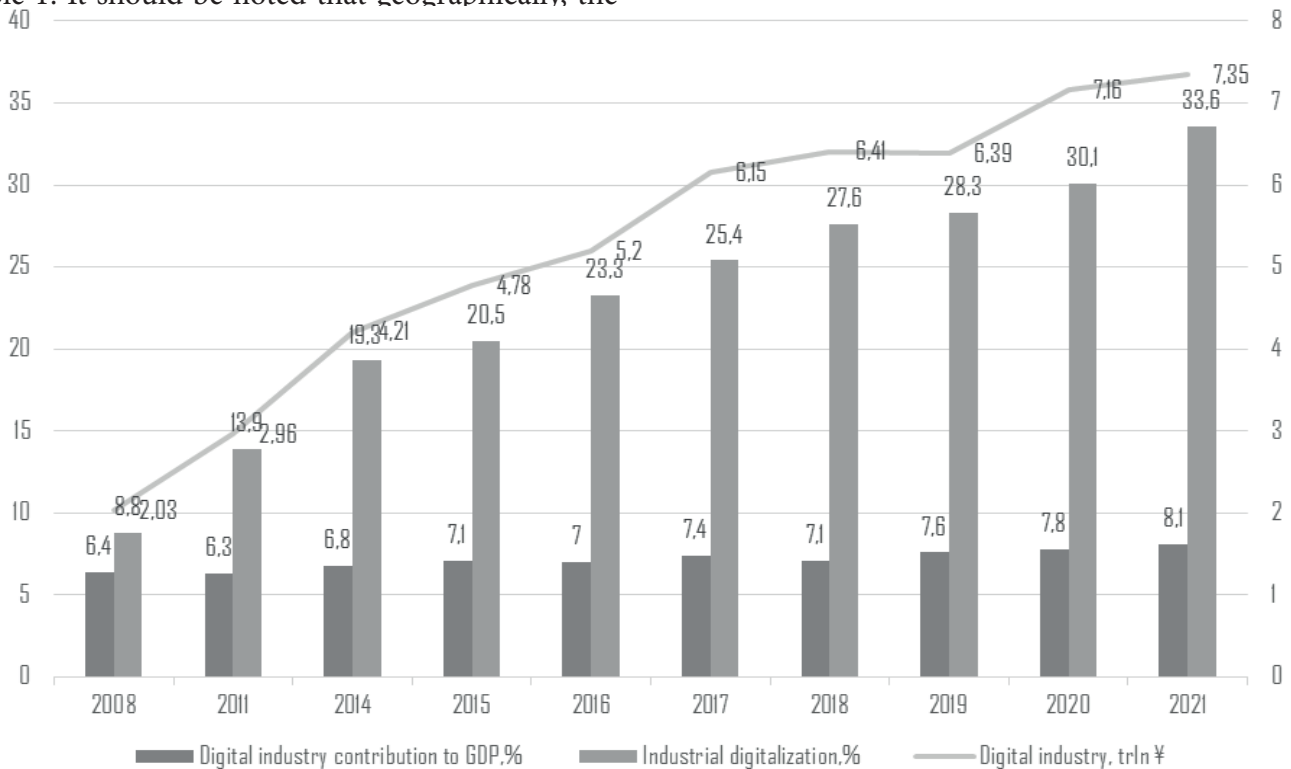


Figure 3. Digitalization of China’s industry, 2008–2021

Source: China Academy of Information and Communications Technology (CAICT, 2022). Retrieved from: <https://academy.itu.int/itu-d/projects-activities/centres-excellence/coe-cycles/coe-cycle-2019-2022/coe/china-academy-information-and-communications-technology>; National Bureau of Statistics of China (NBS), (2022). <http://www.stats.gov.cn/english/>

Table 1

Indicators of digitalization of China’s industry, 2021

Region	Digitalization indicators				Indicators of development of the automotive industry	
	Industrial digitalization index, %	Utilization of special software, %	Level of digital control of key processes, %	Level of digitalization spending, %	Automobile plants	Share of production, %
North China (华北)	34.5	87.0	53.5	2.6	-	-
Northeast China (东北)	29.1	71.2	47.8	2.4	First Automotive Works (Jilin province) BAIC Group (Beijing)	8.1 6.8
East China (华东)	28.9	69.6	48.6	2.1	SAIC Motor Corporation (Shanghai)	11.8
South China (华南)	34.9	87.4	54.3	2.6	GAC Group (Guangdong province)	11.5
Central China (华中)	33.6	88.0	53.8	2.5	Dongfeng Motor Corporation (Hubei province)	9.2
Southwest China (西南)	29.7	70.2	49.4	2.1	LiuGong (Guangxi province)	6.5
Northwest China (西北)	28.1	70.5	49.7	2.1	-	-

Source: China Academy of Information and Communications Technology (CAICT, 2022) <https://academy.itu.int/itu-d/projects-activities/centres-excellence/coe-cycles/coe-cycle-2019-2022/coe/china-academy-information-and-communications-technology>; National Bureau of Statistics of China (NBS), (2022). Available at: <http://www.stats.gov.cn/english/>; China Association for Science and Technology, CAST, 2022. 13 <http://english.cast.org.cn/col/col471/index.html>

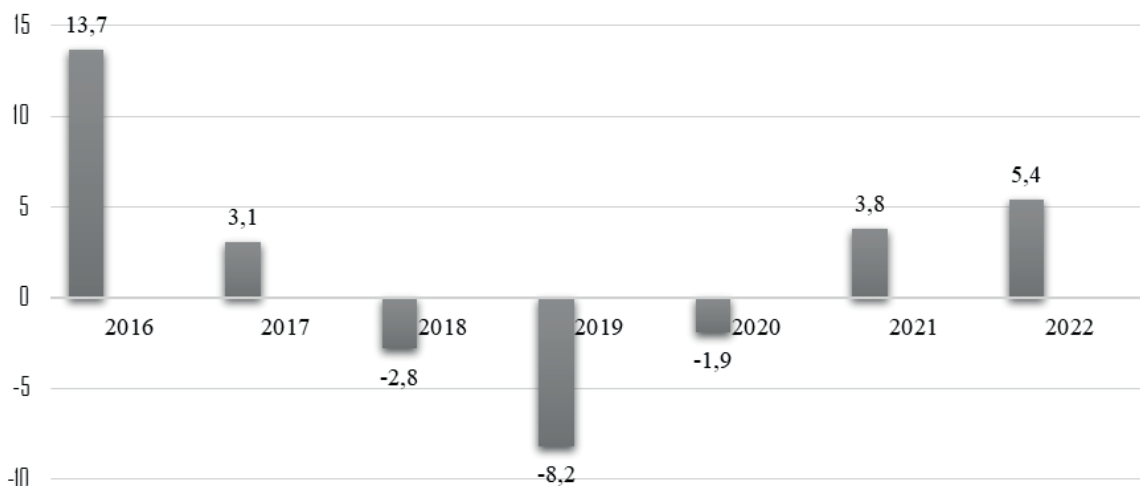


Figure 4. Annual growth rate of car sales in the domestic market of China, 2021, %

Source: China Academy of Information and Communications Technology (CAICT, 2022). <https://academy.itu.int/itu-d/projects-activities/centres-excellence/coe-cycles/coe-cycle-2019-2022/coe/china-academy-information-and-communications-technology>; National Bureau of Statistics of China (NBS), (2022). Retrieved from: <http://www.stats.gov.cn/english/>; China Association of Automobile Manufacturers (CAAM) (2022). Retrieved from: <https://www.oica.net/category/sales-statistics/>

China's automotive industry is one of the largest in the world and is among the most effective high-tech drivers of the country's sustainable economic development. Currently, about 10% of China's GDP is provided by the automotive industry (about \$1.77 trillion)⁴, which has a multiplier effect and enhances the development of adjacent industries, including metallurgical, chemical, petrochemical, electronic and light industries. At the end of 2021, the volume of car production in China increased by 3.4% to 26.08 million units, compared to 2020, and sales increased by 3.8%, to 26.28 million units. In 2022, the growth in car sales was 5.4% (Fig. 4).

Digital transformation is a key strategy for Chinese automakers to meet the challenges of increasing efficiency and competitiveness. Industrial digital transformation of China is driven by the national programs "Made in China 2025" (MIC-2025) and "Internet Plus"⁵. Experts estimate that over 67% of 1000 largest companies in the world and 50% of 1000 largest companies in China have considered digital transformation as a key development strategy and performance factor for digital economy development since 2018⁶.

⁴ National Bureau of Statistics of China (NBS), (2022). Retrieved from: <http://www.stats.gov.cn/english/>

⁵ Made in China 2025 (MIC 2025) (2022) Retrieved from: <https://chinalogist.ru/infographics/kak-kitay-budet-dobivat-sya-statusa-velikoy-proizvodstvennoy-derzhavy-8684>

⁶ China's Digital Economy: Opportunities and Risks. (2019) International Monetary Fund Working Paper. International Monetary Fund. Retrieved from: <https://www.imf.org/en/Publications/WP/Issues/2019/01/17/Chinas-Digital-Economy-Opportunities-and-Risks-46459>

Analysis of the multiplier effects of the automotive industry digitalization conducted by the National Bureau of Statistics of China (NBS) has shown that digitalization created a large number of jobs in the service sector, increasing the multiplier from 1:4.6 to 1:16. According to the new MIC-2025 Industrial Policy, the total digitalization of the global automotive industry will grow at an average annual rate of 16.1% by 2025, reaching \$168.8 billion⁷.

Overall, it can be assumed that, under the influence of the economy digitalization policy, enterprises in China's automotive industry reveal maximum readiness for digital transformation. Digitalization of the supply chains contributes to the economic performance of companies, growth in their operational efficiency, reduction in costs and greater ability to optimize business processes. Moreover, due to the development of logistics outsourcing, companies are increasingly cooperating and collaborating.

Digitalization of regional logistics chains in the automotive industry to address sustainability challenges

The prospects for regional logistics outsourcing in the automotive industry were elaborated in compliance with the principles of sustainable development. The application of digital technologies surely affects supply chain

⁷ National Bureau of Statistics of China (NBS). (2022). Retrieved from: <http://www.stats.gov.cn/english/>

Table 2

Impact of digitalization of logistics outsourcing on the sustainability components of the automotive industry

Component	Target	Method of implementing	Opportunities provided by digitalization
Environmental	Improving resource management to protect natural resource ecosystem	Choosing circular logistics business models that will have minimal environmental impact	Reducing energy consumption and cutting emissions by the supply chain optimization
Economic	Gaining economic benefits along with maintaining the quality of service	Reducing transaction costs while improving the quality of logistics	Decreasing logistics cycle time and increasing productivity
Social	Improving living standards and working conditions	Creating new jobs in supply chain development	Improving working conditions and safety in supply chain management
Technological	Making transition to greener and more efficient technologies to minimize consumption of energy and other natural resources	Using technologies that assure the consistency of business processes	Expanding the flexibility of production and design processes

Source: compiled by the authors

management processes, opening up opportunities to improve sustainability. Table 2 presents the opportunities for digitalization of logistics outsourcing to address sustainability challenges in the automotive industry in terms of the four distinguished components.

In regional logistics outsourcing environment, automobile companies must ensure effective cooperation at all stages to support sustainable development. The chaos caused by the COVID-19 pandemic has paradoxically created ideal conditions for digital transformation in logistics supply chains. Demand fluctuations, unpredictable consumer behavior and disrupted trade links put companies at risk, and simultaneously opened up unique opportunities for top management to make better and more creative supply chain decisions (Chernova et al., 2022; Mitrofanova et al., 2022; Sergeev, 2019).

Digital solutions began to emerge in the logistics industry, involving the internet-based logistics integrators that provide supply chain management throughout the chain. More and more automobile companies are now digitizing their supply chains by integral outsourcing of many logistics service providers. Notably that China is an emerging market in the digitalization of logistics outsourcing with strong annual growth. In 2021, Chinese companies signed outsourcing contracts worth over 970 billion yuan (about \$150 billion) (growth of 27.8% as compared to 2020 and 24.2%

as compared to 2019)⁸. Logistics providers are fully embedded in the concept of the digital economy through virtual relationships, virtual business processes and end-to-end integration between market players. The logistics providers are primarily aimed at transforming the supply chain of a large company into an IT-managed system.

The geography and number of companies providing logistics services for the automotive industry are shown in Fig. 5.

Largely owing to the coastal location and port zones, the following regions demonstrate the largest regional collaboration of logistics outsourcing and vehicle manufacturing: Shandong, Jiangsu, Hubei, Guangdong, Hebei, Zhejiang. In the north-eastern part of China, the First Automotive Works (FAW), Changchun, produces such car brands as BMW, Mazda, Toyota, Volkswagen and Volvo. In Shanghai, the key vehicle manufacturer is Shanghai Automobile and Industrial Corporation (SAIC), which has established several joint ventures: SAIC GM Wuling Automotive, SAIC Iveco Hongyan and Shanghai Advanced Traction Battery Systems Co. South China (Guangdong province, Hong Kong, Macao) is home to the largest automotive industry cluster, including Nissan, Honda and Toyota, which brings together contractors of a variety of spare parts and components.

⁸ China's Digital Economy Plan for the 14th Five-Year Plan (2021-2025) (“十四五”数字经济发展规划) Retrieved from: http://www.gov.cn/zhengce/content/2022-01/12/content_5667817.htm

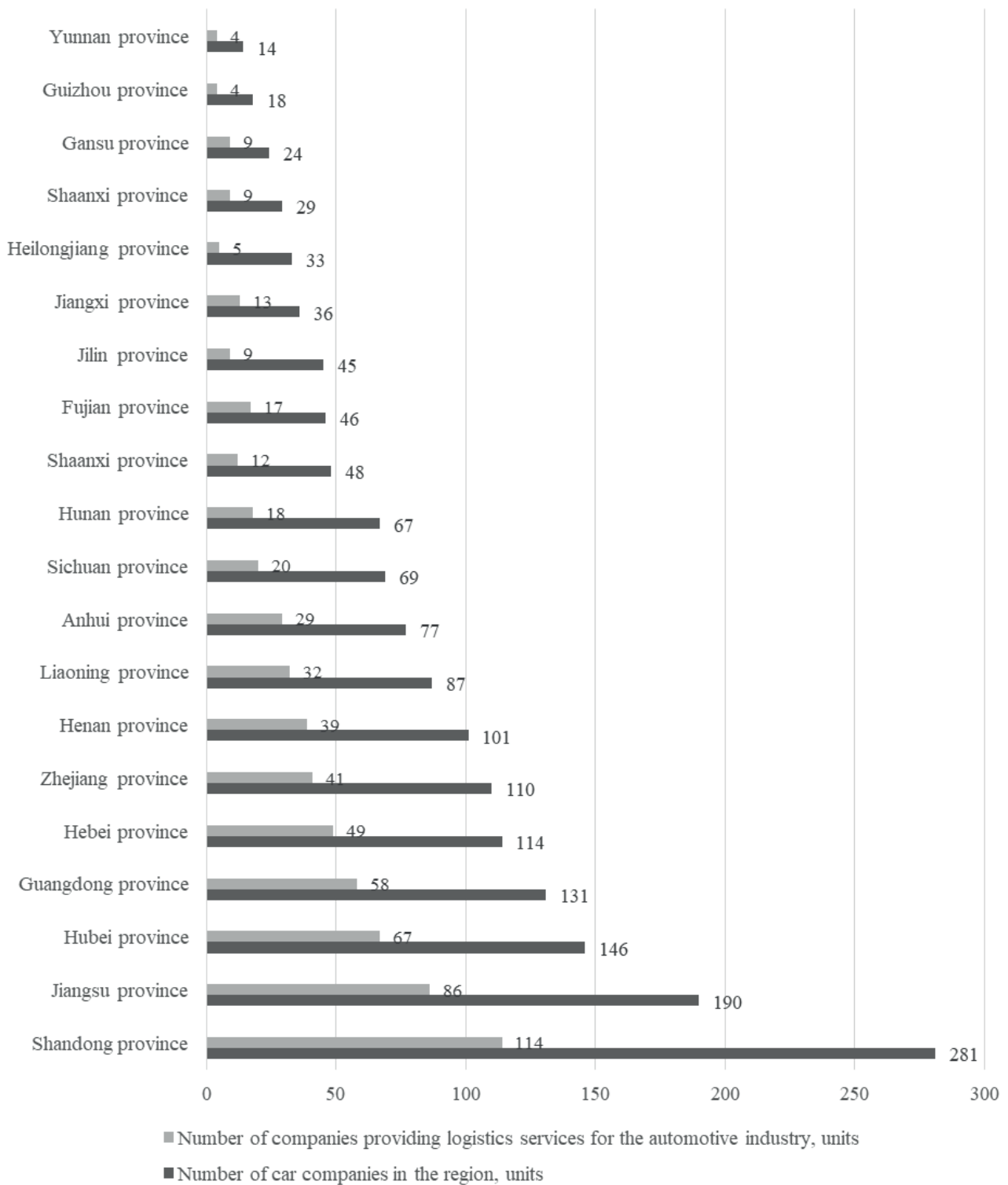


Figure 5. Number of organizations providing logistics services to automobile companies by region in China

Source: Compiled by the authors according to logistics service provider websites. Retrieved from: <https://auto-che.ru>; <https://ru.made-in-china.com/manufacturers/logistics.htm>; <https://ru.made-in-china.com/manufacturers/shipping-company.html>; <https://ru.made-in-china.com/manufacturers/international-logistics-services.html>

Table 3

Effects of digitalization in logistics outsourcing on the sustainability of the automotive industry

Digital technologies	Components of sustainable development			
	Environmental	Economic	Social	Technological
Artificial intelligence	Reducing “paper waste” as a result of switching to e-document management	Possibility to improve forecasting of business conditions	Improving the efficiency of interaction with customers and partners	Increasing efficiency of decision-making
Internet of things		Monitoring business processes in real time	Better time management	Automation of core business processes
Blockchain		Reducing risks of supply chain disruption	Increasing information security	Increasing transparency of operations throughout the supply chain
Robotics		Reducing costs and increasing productivity	Reducing human factor and maintenance errors	Automation of routine tasks

Source: compiled by the authors

The most common digital technologies, being introduced in regional logistics outsourcing, include artificial intelligence, Internet of things, blockchain and robotics. The potential benefits of implementing these technologies in terms of improving the sustainability of the automotive industry are presented in Table 3.

However, in order to enable such effects to be emerged, the digital logistics outsourcing ecosystem model should be implemented, involving a transformation across the entire supply chain management system for sustainable development of the automotive industry.

Conceptual Framework for a Digital Ecosystem of Regional Logistics Outsourcing in the Automotive Industry

In case of regional logistics outsourcing, supply chain management is carried out in the country's domestic market; its framework hence should be developed in relation to the national context.

The Chinese domestic transportation market is characterized by a high degree of fragmentation. The country lacks uniform regulations and standards for logistics, outsourcing and contracting activities. Competences of workers vary significantly in different regions. Fragmentation is also reflected in the diversity of the IT solutions used by automobile companies in individual business processes. For example, the SAP supply chain management system is used in Shandong province (home to FAW Group), a major automobile manufacturer. The Infor SCE logistics management information system is operated in Hunan province, where the Changan automobile plant is located. Different software products can also be

used in warehouse management systems. For example, the Kewill warehouse management system is operated in Hebei province, where a large Great Wall Motors plant is located. The LXE warehouse management system is used in Shaanxi province, where the BYD automobile plant is situated.

The emerging framework for a digital ecosystem of regional logistics outsourcing in the Chinese automotive industry needs to handle the fragmentation problem. The solution might be found in implementing the logistics ecosystem model developed by French technology company Capgemini. On its bright side, the model provides a versatile approach to logistics management, including supply chain management, and also ensuring software compatibility as well as managing the interactions of chain actors, etc.

This model identifies three main components of the digital logistics ecosystem:

- Full digitalization of end-to-end processes that characterize a transaction;
- Availability of a digital operating model that enables the level of centralization of individual functions to be determined by managers independently;
- Ability to digitally manage corporate assets⁹.

Development of a digital framework for a regional logistics outsourcing ecosystem in the automotive industry implies industry specific considerations, expressed as follows:

1. It is necessary to bring all members together in the value chain on a single platform,

⁹ Digital Transformation of Supply Chains. Creating Value – When Digital Meets Physical // Capgemini. URL: <https://www.capgemini.com/wp-content/uploads/2017/07/Digital-Transformation-of-Supply-Chains.pdf>

which can be generally represented by manufacturer, distribution, dealer and consumer channels. At the same time, an important feature of the automotive industry is the involvement of economic agents of various scales and activities in the logistics business processes: automobile companies, warehouses, freight terminals, insurance companies, etc. (Mikhailov, 2011), using different software products in their logistics, which significantly increases the requirements to ensure trust between the members. As Li and Petruzzi noted, in an outsourcing relationship, trust in ability and goodwill are essential for co-operation (Li, Petruzzi, 2017).

2. Given the specific nature of automotive industry logistics, the supply chain ecosystem should include microservices (e-document management, order distribution system, cargo insurance system, counterparty verification system, payment system, cargo routing unit, contract generation services, shipment document and waybill generation services) that integrate the internal operational data from all supply chains of the company with data from external sources on a single platform.

3. A separate microservice “Logistics Outsourcing” should be developed in order to engage partners (outsourcing companies) in individual business processes on a regular or ad hoc basis. Here, automobile companies should be able to assess the performance of outsourcers and see their rating.

4. Throughout the value chain, all members should be given access to seamless data exchange and the necessary information to fulfill its end-to-end processing. Such open loops will minimize duplication of non-value added activ-

ities (e.g. double data entry, obtaining information from different sources). At the same time, it is fundamentally important to allocate “closed” loops in the ecosystem to ensure the interaction of a separate set of agents working on a particular project.

5. Relevant tools should be applied to ensure the reliability of the data provided. This requires the system to be constantly updated with real-time information. Insufficient visibility of cargo, delayed information on its location, on payment, etc., are major causes of fraud and counterfeiting (Pun et al., 2021).

Based on these considerations, the conceptual framework of a regional digital automotive logistics outsourcing ecosystem can be presented as follows (Table 4).

The suggested framework provides opportunities to improve the sustainability of the automotive industry across all its components:

- In relation to technological sustainability – greater freedom of choice in making management decisions is ensured with the necessary degree of concentration of data on a single platform, including data on the companies in the supply chain as well as on region-specific factors and conditions of their geographical location;
- In relation to economic sustainability – the integration of operational and financial data enables the supply chain performance to be more accurately assessed at individual stages;
- In relation to social sustainability – the quality of interactions with suppliers and customers is improved and the level of trust between them is increased;
- In relation to environmental sustainability – the volume of physical waste treatment is reduced.

Table 4

Conceptual Framework for a Digital Ecosystem of Regional Logistics Outsourcing in the Automotive Industry

Components of a digital ecosystem as recommended by Capgemini	Content of Component	Conditions for sustainable development of the automotive industry
Digitalization of end-to-end processes	Ecosystem microservices: business process services, financial services, logistics outsourcing services, etc.	– Seamless data exchange – Parallel loops – Real-time operation
Digital Operating Model	Strategic plan of supply chain actors for the development of digital infrastructure	– Consistency of strategic digital infrastructure plans of supply chain actors – Using data in line with the business strategy of the automobile company
Digitalization of corporate asset management	Digital accounts of supply chain actors	– Ensuring the reliability of user data – Personal data security

Source: compiled by the authors

Overall, the integration of logistics business processes on a single digital platform is considered to create the prerequisites for increasing sustainability of the automotive industry by making supply chains flexible, integral and lean, and by increasing the value of the services provided to the consumer. At the same time, the sustainability of the automotive industry is ensured by tackling the problem of fragmentation of the logistics services market.

The suggested framework for a digital regional logistics outsourcing ecosystem for China's automotive industry can be implemented on a basis of the national transport and logistics platform LOGINK¹⁰, which integrates the information flows of all ports, railway stations and airports in the country. At present, this platform is predominantly used by small and medium-sized companies. However, it can also be applied by automobile companies, with the platform functionality being further developed through the use of open source software products.

The current Chinese IT market could provide IT solutions supporting the presented digital logistics outsourcing ecosystem. For example, the following open source products can be proposed as possible applications:

- LYNK & CO is a digital platform for automobile sales management, which also includes services related to supply chain management and logistics¹¹;

- Baidu Apollo is an open platform for developing automobile artificial intelligence systems provided by the Chinese company Baidu. Apollo provides solutions for various tasks in the automotive industry, such as navigation, fleet management, vehicle diagnostics, etc.¹²;

- CANGO is a cloud-based platform for management and analysis of automotive data. CANGO provides solutions for traffic management, fleet management and electric vehicle monitoring¹³;

- CSDN Auto is a digital platform provided by the Chinese company CSDN for the development and integration of software products in the automotive industry. CSDM Auto also includes solutions for automotive software testing¹⁴;

¹⁰ Logink. Retrieved from: <https://www.logink.cn/>

¹¹ Simple, Flexible, Shareable | Lynk & Co. Retrieved from: <https://www.lynkco.com/en>

¹² Apollo. Retrieved from: <https://developer.apollo.auto/index.html>

¹³ Cango Inc. Retrieved from: <https://cangomobility.com>

¹⁴ Source: CSDN - 专业开发者社区. Retrieved from: <https://www.csdn.net>

- SAIC Mobility is a digital platform developed by China's SAIC Company for traffic management and services governance in the automotive industry. SAIC Mobile provides solutions such as fleet management, vehicle monitoring, logistics management, etc.¹⁵.

These platforms are the most popular in China, with certain advantages in either speed or “understandability of commands”. Therefore, the particular choice between platforms is determined by the need to solve certain types of tasks and the possibilities of “extending” the functionality.

Thus, China currently has prerequisites for the development of unified digital model of regional logistics outsourcing in the automotive industry. Despite the fragmentation of the transportation market noted above, the development of digital logistics outsourcing appears to go a long way towards creating common standards of interaction, thereby reducing information asymmetry in supply chains and increasing trust among its members.

Conclusions

The complex business environment is increasingly forcing companies to revise their strategies, encouraging them to focus on core competencies and outsource non-core business functions. Logistics outsourcing for the automotive industry is no longer an option but standard practice. The driving forces behind digitalization of logistics outsourcing processes in the automotive industry are numerous and can be viewed in terms of its environmental, social, economic and technological components in order to enhance sustainability.

It was concluded that digitalization of regional logistics outsourcing will contribute to increasing the sustainability of the automotive industry. However, this requires the formation of a digital landscape of logistics outsourcing, which involves changes in the entire supply chain management system. The present study identified the most common digital technologies implemented in regional logistics outsourcing practices to improve sustainability of the automotive industry and outlined the possible benefits of their implementation. The logistics ecosystem model developed by Capgemini was supplemented by the conceptual framework of the digital logistics outsourcing ecosystem for the automotive industry. The contribution of the authors involves investigating

¹⁵ SAIC Mobility Robotaxi. Retrieved from: https://www.saicmotor.com/english/latest_news/saic_motor/56570.shtml

the main components of the digital ecosystem to enrich them with details, taking into account the specifics of automotive industry logistics, as well as the determination of the basic conditions for the design of this ecosystem in terms of creating the prerequisites for improving sustainability of the industry.

The theoretical significance of the study is expressed in the development of theoretical grounds for logistics outsourcing in the context of Industry 4.0 and the imperatives of sustainable development. The practical significance of the study involves the possibility of using the developed logistics outsourcing ecosystem framework to address the challenges of improving supply chain management in the automotive industry.

The main limitation of the present study is its close relation to the digital trends associated with the current state of the Chinese automotive industry. The study is focused on regional logistics, while the international logistics has its specific nature in terms of cross-border flows management. In order to form a digital ecosystem for international logistics outsourcing, as well as for logistics outsourcing in other countries, suggestions offered here should be adjusted to the digital landscape of a specific region. Being aware of this limitation, the authors will concentrate further research on the development of a methodology for assessing the capacity of automotive industry to implement digital transformations in its core business processes.

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ARTICLE INFO: received November 27, 2022; accepted May 5, 2023

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ИНФОРМАЦИЯ О СТАТЬЕ: дата поступления 27 ноября 2022 г.; дата принятия к печати 5 мая 2023

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