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Modern problems of logistics risk management in supply chains in the digital economy

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Abstract. This study examines by emphasizing digital economy dynamics, logistic risk management within supply chains. The introduction highlights the aims and objectives of the research as well as development strategies and viewpoints, so putting the study in a larger framework. With an eye toward the modern difficulties of logistic risk management in supply chains, the study places the problem within the dynamic terrain of the digital economy. To clarify the complex nature of logistic risks inside digitally integrated supply chains, the study uses a range of techniques including statistical analysis, case studies, and survey. The study's key findings center around the complexities and potential vulnerabilities that arise within digitally operated supply chains, shedding light on the dynamic nature of logistic risks in this context. By synthesizing the research, key interpretations and insights will be presented, underscoring the critical importance of adaptive and resilient strategies for effectively managing logistic risks in modern digital supply chains. This abstract aims to encapsulate the essence of the paper, offering a concise overview of the scope and significance of the research on logistic risk management in the digital economy.

Keywords: logistics risk, supply chain risks, risk classification, risk assessment, risk management system

Introduction

Reducing system hazards is one of the primary goals of supply chain management (SCM). Using a multi-layered security approach, effective supply chain security seeks to rapidly identify, evaluate, and prioritize logistical threats for management. This necessitates meticulous preparation of the whole manufacturing-related corporate infrastructure, including the supply chain and other assets. Legal systems, such as those pertaining to national security and customs

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rules that are pertinent to supply chains abroad, are also considered by companies when they secure their supply chains.

In order to guarantee the supply chain, it is necessary to first identify any potential system vulnerabilities. It is important to recognize and adapt methodologies from enterprise risk management in general to mitigate and eliminate these risks. Businesses have to give supply chain security top priority since disruptions in supply chain links can cause financial damage or compromise general operations. Product spoilage, inefficient shipping, and unnecessary costs are all results of supply chain weaknesses. Also, clients can end up hurting and spending a ton of money on legal fees because of service or product failures or late deliveries. Logistics risk management systems strengthen supply networks, making them more resilient to various threats.

While it's hard to eliminate all risks, companies may mitigate them with effective supply chain management, which can lead to safer and more efficient deliveries and quicker recovery times. Immediate action is required to resolve issues with logistical risk management. Today, risk is inherent in every strategy and tool used by corporations to further their economic policies. In this sense, it is natural for any company to want to lower the losses connected to the execution of risk in logistics operations.

The purpose of the study is a theoretical and methodological analysis of logistics risk management processes at industrial enterprises.

Research methods - theoretical analysis of scientific literature, systematization, interpretation of conceptual judgments, empirical methods, comparative analysis.

To achieve this goal, the following tasks have been identified:

– Examine the theoretical underpinnings of the selected research topic;

– Identify elements and find strategies to lower risks by means of railway transportation;

– Find the method for managing logistics risks in line with the chosen case to decide on risk policies.

Literature Review

Currently, a large and growing number of scientific studies are devoted to the issues of uncertainty and risk related to the logistics industry. Modern companies operate in conditions of increased uncertainty and dynamics, so they need to flexibly adapt to changing environmental conditions. The constantly expanding zone of influence of logistics correspondingly increases the number of processes and risk situations that may arise in the logistics activities of the company. Modern companies operate in conditions of increased uncertainty and dynamics, so they need to flexibly adapt to changing environmental conditions. In an increasingly knowledge-based, information-based economy, the ability to anticipate certain events and adjust company policies accordingly is especially important [1].

Risk refers to the likelihood of an event that could negatively affect the process of achieving company goals [2]. The efficiency of logistics systems is inextricably linked with risks, which determines the need for continuous development of risk management methods and tools [3]. Decisions and actions, including risk analysis and strategy development to minimize them, are part of risk management, which aims to provide the desired financial outcomes and conditions for the company's ongoing expansion [4].

Risk is a complex phenomenon that has many divergent and sometimes opposing foundations and prerequisites. This makes it possible to have several definitions of risk concepts from different points of view [5]. In the current economic environment, it seems necessary to systematically identify and analyze risks that affect business processes and their performance in order to ensure the survival and competitiveness of the company. In addition to achieving goals, risk assessment can also help improve a company's business processes. The efficiency of logistics systems is inextricably linked with risks, which determines the need for continuous development of risk management methods and tools [6].

Despite the importance of the issue under consideration and the rapid development of risk management, it should be emphasized that there is still a need to develop methodological support for risk management of logistics systems due to the lack of practical methods for risk analysis and assessment. Fast changes in the business environment result in the development of new hazards and their categories as well as complicate logistics processes, which results in the necessity of better risk classification and analysis technique approach [7],[8].

Since "logistics" and "supply chain management" are conceptually similar, scholars [9] have defined logistics risk as an unforeseen, unfavorable event that causes the non-availability of required materials at the specified time, in the specified quality, and at the specified location, all at the specified cost.

Risk management in logistics is complicated by a number of barriers, including centralization of product distribution, changing consumer expectations, lack of necessary information, difficulties in managing information flows and outsourcing processes, and differences in standards used by partners [10]. The authors also fail to provide or substantiate any reasoning for the specific logistics risk rating criteria they employ, with very few exceptions. It is common practice in logistics to refer to potential dangers as "external factors influencing the system's reliability."This includes risks associated with the reliability of management, the reliability of operational scheduling for incoming and outgoing flows, and the appraisal of insurance or regulatory reserves.

According to the author [11], logistics risk is a management concern when there is a chance that business processes may fail or become inconsistent as a result of certain events. The severity of these failures or inconsistencies will determine whether the intended outcome is exceeded or not achieved under different conditions. A particular point of view is that "logistics risks amalgamate diverse risk types from all constituent links and elements, both during the alteration of material, financial, and information flows, and in the actual management of risks that emerge within the logistics system" [12].

The authors [13] outline the characteristics of logistics risks within the context of business hazards, limiting their focus to customs risks, delivery disturbance risks, and damage sustained during logistical operations at every stage of the supply chain. Also detailed in the policy's exclusions and conditions are the logistical hazards that can arise during the insured conveyance of highly expensive items. Along with the "logistics risks," there is also the "transport risks" category, which is further subdivided into "hull insurance" risks (that come from vehicles) and "cargo" risks (that come from goods that are transported by vehicles); the latter is sometimes referred to as logistics risks by some writers.

The major components of the economic system are "flow - process - system characteristic - subjective factor," and the authors of [13] proposed a technique for classifying business risks

based on this logical order. In [14] the first attempt to define the term, codify the classifications of logistics risks inside domestic scholarly literature, and separate "logistics risk" as a unique entity was done. Logistics and supply chain risks are classified according to "risk centers," which encompass infrastructure resources and facilities and functional subsystems like "warehousing and storage" and "service." Operations, infrastructure, supply chains, logistics systems, and the environment are some of the higher tiers into which they are classified using a process-oriented approach. The author, drawing on the definition of hazards in supply chains [15], suggested "an activity factor defined by specific conditions of occurrence, intensity of action, and resource potential, simultaneously functioning as an indicator, integrator, and regulator of the supply chain's state." Risk improves the supply chain's and its components' competitiveness by removing roadblocks and directing attention to critical success factors.

The phrase "supply chain risk" is more commonly used in academic and research journals than "logistics risk" or any of its synonyms. It is common practice for research institutes and enterprises worldwide to use a variety of approaches, and the many stages of logistics and supply chain management idea development serve to highlight these distinctions [16].

Supply chains are increasingly using various innovations, both in management and in warehousing and storage of products, so they need to be taken into account when managing risks.

Companies are always seeking for strategies to have a competitive advantage and enhance their operations in the fast-paced business environment of today. The change of conventional supply chains into digital ones is among the most important changes of recent years. This change is not only a trend; for companies trying to flourish in the digital era, it is a strategic need. With the increasing spread of digitalization processes, all customers today expect accessibility, personalization, low cost and high value. In the modern world, the digital economy plays an increasingly significant role in the management of logistics processes. In this regard, the analysis of logistics risk management in supply chains becomes a key aspect of the successful activities of organizations. However, the methodological foundations of risk management remain unexplored.

Research by scientists emphasizes the need of the following fields, which have not received enough attention:

– integrated approach: Many experts advise using an integrated approach for risk management, which combines operational, tactical, and strategic management.;

– proactive methods: the use of proactive methods allows you to prevent potential risks and develop measures to minimize them even before problems arise;

– methods of logistics risk management;

– risk assessment: conducting a systematic risk assessment, which allows you to identify vulnerabilities in supply chains and take appropriate measures;

– use of technology: Using digital technologies including blockchain, machine learning, and big data analytics helps to forecast risks more precisely and manages logistics operations;

– The development of digital technologies makes it feasible to automate many logistics operations, so helping to lower risks and improve supply chain efficiency by means of automation and process optimization;

– data mining: the use of artificial intelligence and data analysis allows you to more accurately predict risks and make more informed management decisions.

Methodology

A systematic review approach is used to comprehensively review the scientific literature using quantitative and qualitative methods.

The research methodology is based on the use of general scientific methods, including analysis, generalization, induction, deduction, synthesis, classification, etc. The improvement of the risk analysis approach presented in the paper depends on the application of a risk register, mathematical methods, professional knowledge, and risk evaluation tools. The required information about possible hazards resulting from the execution of particular procedures is produced using the risk register; it is then analyzed and appropriate action is developed to either prevent or reduce the effects of risk events. This tool can be used to identify and assess the risks of a company as a whole, as well as to assess the risks of its systems, including purchasing management, inventory management, product manufacturing, etc. The risk register should be reviewed and updated at regular intervals to ensure continuity of monitoring.

The SWOT analysis that was used in our study served as an effective tool for analyzing the current situation and the basis for developing strategic directions for development.

Table 1 – SWOT analysis of railway transport

Strengths	*Weaknesses*
– Kazakhstan's strategic location between the economic powerhouses of the EU and China facilitates cargo flows, as well as access to the markets of Russia and Central Asia; – a basic network of main railways has been established; a transport logistics system centered on railway transportation is under development; – a great degree of integration of Kazakhstan's railway segments into international corridors has been achieved; – the market for goods forwarding services and rolling stock operators has been cultivated.	– Unsettling customs procedures; inconsistent electronic recognition; – new customs documentation needed for transit cargo; – significant deficiencies in physical and mental infrastructure and rolling stock; – infrastructure is engineered for low base high speeds; – flawed methodology for tariff calculation; – government mortgage programs lack adequate financial resources for infrastructure modernization and construction; – inconsistency between government measures and carrier strategy.
Possibilities	*Threats*
– increasing the capacity for cargo transportation as a result of Kazakhstan's mining industry's development; – drawing in more transit cargo through the building of new routes and railways; – improving and simplifying access to railway infrastructure; – speeding up cargo transportation through innovation and modernization.	– the development of new alternate transit routes in neighboring nations; – a decrease in transit cargo volume due to slow cargo transit speeds; – a rapid decline in the moral and physical integrity of the fleet of vehicles and locomotives; – the entry of foreign businesses into the Kazakh railway transportation market.
Note: used source [17]	

A total of 100 companies were recruited and agreed to take part in the survey. In all companies, respondents mainly worked in the field of operational management, for example, operations managers, supply chain managers. To assess risks using the method proposed in the study, it is necessary to determine the impact of the identified risks on the processes and results of the company's activities under consideration, using the method of expert assessments. The theoretical basis of the study consists of scientific articles by foreign researchers in the field of analysis and management of risks arising in the activities of companies, including the risks of logistics systems.

Theoretical analysis of scientific literature showed that theoretical and practical issues of managing logistics risks in CP are considered in the works of domestic and foreign scientists and specialists studying the problems of SRM and integrated logistics, in terms of studying the properties of CP, characterizing their response to risks, as well as developing methods for increasing stability and reliability of the CPU in relation to risks.

Risk management is the process of making and implementing management decisions that minimize the adverse impact of damage caused by random events. The relevance of studying the subject of the emergence of logistics risks (or risks in supply networks) cannot be underestimated. Research done as part of an initiative by Oracle Corporation found that whilst 63% of European firms encounter unexpected breakdowns in "value chains," the vast majority of which are artificial, 77% of Russian organizations do. According to our data, a significant majority of the firms in Kazakhstan are currently facing problems with their supply chains. At the same time, the indicator for the manufacturing and construction industry is among the highest, sitting second only to the transportation sector, which is shared with enterprises in the financial sector. Among the Kazakh businesses that took the survey, just 30% claimed to have done a comprehensive risk assessment. Companies that had a disruption to their value chain over the last year took an average of almost 60 days to go back to normal. On a per-event average, corporations spent $600,000. This amount covered things like product recalls, lost sales and customers, and chain restoration procedures. At roughly $30k for event, our survey in Kazakhstan indicated that these expenses were lower than the norm for the region. Results from such a study could cast doubt on the sample's qualitative diversity, considering that respondents from different industries used the same questionnaire. Also cast into doubt is the reliability of the assessment criteria and the likelihood of competing definitions of the terms used. Nonetheless, a different poll confirmed what many have suspected for some time: that 70% of respondents do not have an in-depth understanding of the threats and interruptions that can affect their supply chain. Much of the aforementioned literature examined supply networks through the lens of external, macro-risks. Risks associated with the supply chain have been identified in other studies. Consequently, a worldwide evaluation carried out by the Allianz group of insurance companies towards the end of 2021 established this category as the most critical among the ten main business risks for 2022. (Figure 1).

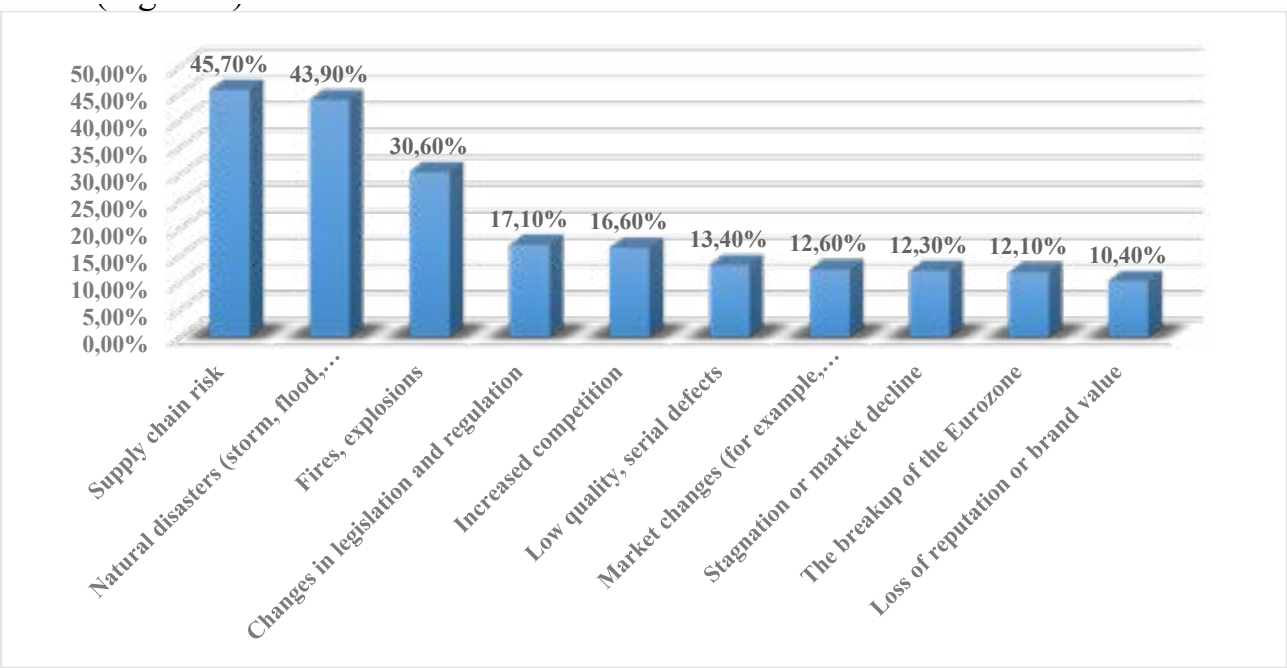

Figure 1 Top 10 business risks in 2022. used source [17]

In the annual Allianz Risk Barometer reports for 2023 and 2024, supply chain disruption risks ranked as the second most critical threat. Among 3,000 risk management experts from over 90 countries, 34% of respondents in 2023 attributed supply chain disruptions to the following factors: cyber incidents and attacks on digital logistics platforms; geopolitical conflicts (particularly the war in Ukraine); energy crises and inflation, leading to increased costs and logistical bottlenecks; a growing emphasis on localization and reduced global dependencies.

In 2024, 31% of respondents identified the primary drivers of supply chain disruption risks as: Climate-related disasters (e.g., drought in the Panama Canal, hurricanes, floods); Geopolitical instability and attacks in the Red Sea region; the threat of advanced cyberattacks, including AI-enabled attacks; rising protectionism and trade restrictions.

Table 2. Comparative Table of Supply Chain Disruption Risks (2023–2024)

Year	The place of risk of supply chain interruption	% mentioned	The main factors	Retaliatory measures
2023	2nd place	34	Geopolitics, energy, information technology	Diversification, localization
2024	2nd place	31	Climate, cyber risks, geopolitics	Supply chain continuity management (identification of critical processes and what losses are possible if they fail.), organization of alternative supplies
Note: used source [18]				

A Deloitte study supports the findings [19]. Supply chain risk groups conducted the survey. Among the many potential threats to the central company's operations along the supply chain, "internal" threats account for 63% of the total, while threats arising from interactions with supply chain partners account for 46% and 35%, respectively 2 (Figure). concerns with counterparties (suppliers and partners) across the supply chain, including demand fluctuation, rivalry, order fulfillment concerns, and shortages, are the main problems discovered.

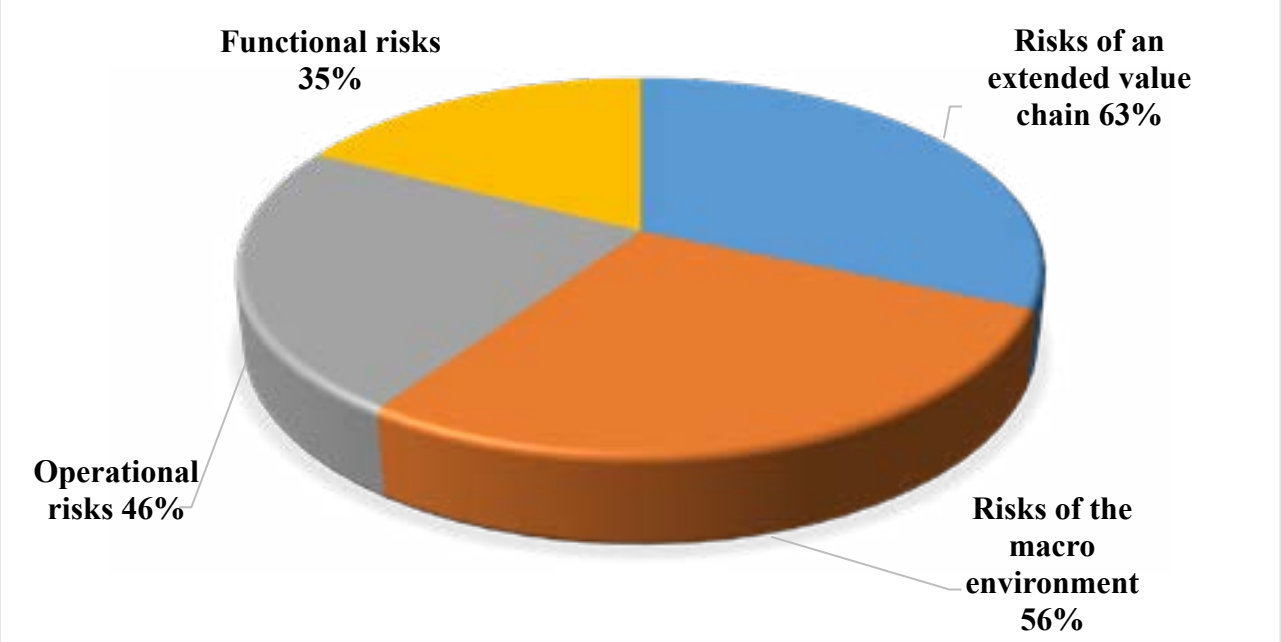

Figure 2 Ranking of risks in the supply chain by degree of importance.
used source [19].

Both the frequency (48% rise, 31% little increase/consistency) and the costs (53% increase, 31% modest increase/consistency) of risk occurrences have been reported by the majority of respondents as having increased. Only 50% of companies think their supply chain risk management program is successful, even though 63% of those companies have one. This is another important conclusion that should be taken into account from the study. The main reasons for this include a lack of a comprehensive or systematic definition of risk in supply chains, insufficient or limited supply chain information, high implementation costs, lack of designated "owners" for the risk management process at the strategic and tactical levels, insufficient cross-functional coordination, and flawed control systems that make it difficult to assess the effects of risk events compared to the potential effects of risk management interventions.

Research shows that not even the most successful companies in the world reliably deal with supply chain risks. According to PWC's forecasts for 2021, a research conducted in 2009 found that supply chain delays caused a performance decrease of more than 3% for more than 60% of the top worldwide firms.

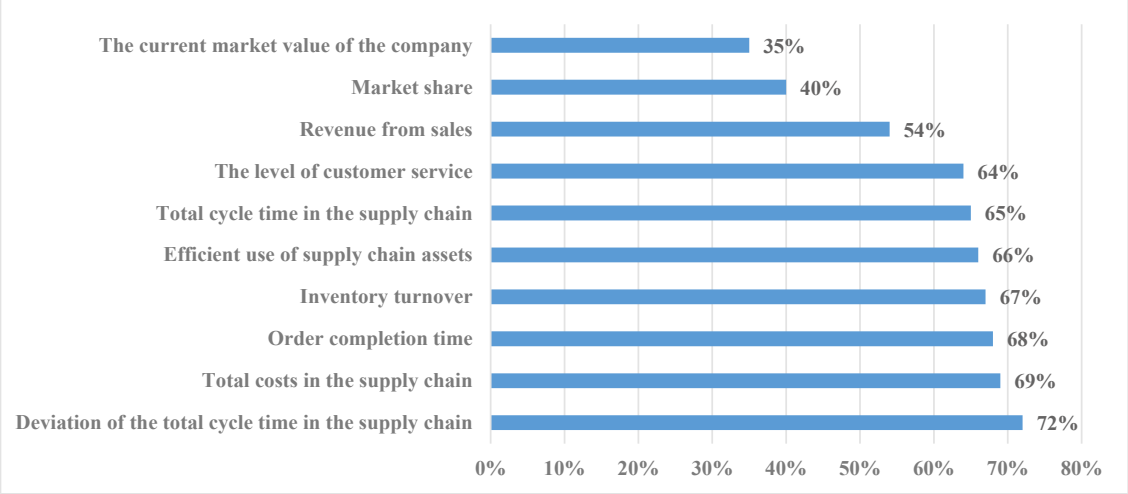

Figure 3 Percentage of companies whose supply chain disruptions led to a deterioration in performance indicators of more than 3%.

used source [20]

The lack of importance of controlling objectives such as supply risk minimization, transparency of logistics costs and procedures, and preparation of decision-making information demonstrates that the impact of logistics risk management on improving a company's primary logistics performance metrics is underappreciated. See Figure4.

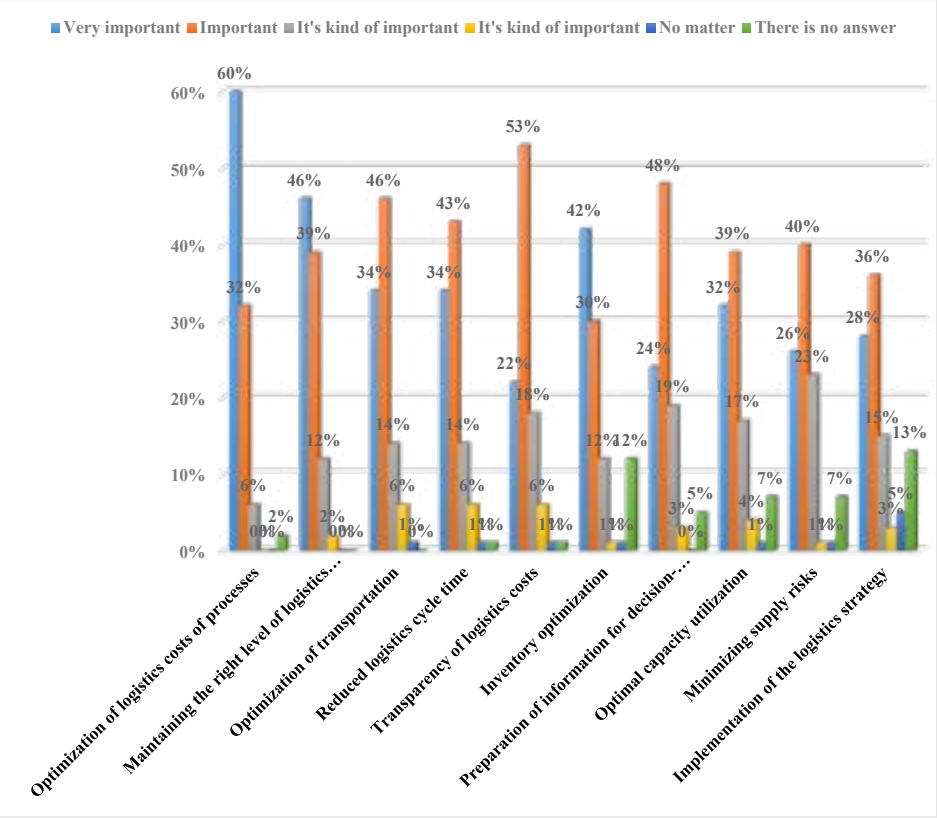

Figure 4 The importance of logistics controlling targets.

used source [19]

The following categories of logistics risks are the focus of current domestic research: transportation (by mode of transportation, for example, logistics company traits, logistics outsourcing, supply, people, inventory management, warehousing, etc.). Therefore, corruption risks in the operations of the national company "Kazakhstan Temir Zholy" have been identified by the anti-corruption service.

They are associated with administrative barriers and corruption schemes when supplying cars, lack of proper digitalization, direct contact between railway workers and entrepreneurs, and submission of applications in paper form. The identified corruption risks are confirmed by criminal statistics.Thus, over the past 5 years, 136 criminal cases have been registered against officials of Kazakhstan Temir Zholy and its subordinate organizations. 52 people were convicted under them. The majority of crimes in this area are cases of bribery (70%) and theft (13%).

Key steps in risk management at Kazakhstan Temir Zholy may include the following:

– Identification of risks: a company must identify all possible risks that it may encounter in the course of its activities. These can be both financial risks (changes in exchange rates, inflation) and operational risks (technical failures, accidents).

– Risk assessment: following the identification of possible risks, it is vital to evaluate the likelihood that they will materialize and the effect they will have on the business operations of the organization. There are several ways to accomplish this, including sensitivity analysis and risk matrices.

– Creating risk management plans: The business needs to create risk management plans based on the findings of the risk assessment. These can be tactics for reducing adverse effects (such as concluding insurance policies) or risk prevention (such as introducing new technologies).

– Monitoring and Control: Risk management is a process that requires constant monitoring and control. The company must regularly review its activities to identify new risks and the effectiveness of risk management measures taken.

An example of how risk management can be applied in the Kazakhstan Temir Zholy company could be reducing the risks of emergency situations on the railway by introducing modern technologies for monitoring and preventing possible accidents. The company can also insure its assets and personnel against possible accidents to minimize potential financial losses.In general, risk management plays an important role in ensuring the sustainable and successful development of Kazakhstan Temir Zholy and protecting its interests in the market.

Railway companies such as Kazakhstan Temir Zholy (KTZ) face a variety of logistics risks in their operations. In this review, we will consider approaches and methods of risk management using the example of the KTZ railway company.

The following approaches to risk management are considered:

– Development of a safety culture: One of the key approaches to risk management at KTZ is to stimulate a safe culture among staff and create conditions for preventive control and risk prevention.

– Integration of technologies: The introduction of digital technologies allows KTZ to increase the transparency of logistics processes, which contributes to the early identification of potential risks.

The following risk management methods are proposed:

– Conducting safety audits: Regularly conducting safety audits and assessments of railway operations helps identify vulnerabilities and develop safety improvement measures.

– Education and training of staff: Teaching staff members about safety issues and how to react behaviorally to hazards improves awareness and preparedness to act in emergency situations.

Use of IoT and data analytics: KTZ is able to create a framework for tracking and evaluating railway network operations thanks to the development of the Internet of Things and analytical tools, which makes it easier to identify threats early and take prompt action.

Enhancing the risk management system: KTZ is committed to the ongoing enhancement of the risk management system via systematic evaluation of the efficacy of risk mitigation strategies and the implementation of best practices.Logistics risks are intricately linked to the management of commodities and information flow, with potential interruptions in the logistics system due to unfavorable events in its subsystems or the external environment. Under these circumstances, there is a growing necessity for efficient risk management in logistics, grounded in the procedures of recognizing and analyzing potential hazards.

Findings

To sum up, keep in mind the following details. There is a lack of consensus in both the academic and professional communities of logistics regarding the meaning of the phrases "logistics risk," "risks in logistics systems," and "supply chain risks," as well as the connections between these concepts. Given the essential importance of the issue in a dynamic and hostile environment, the scientific community is actively conducting research to further the idea of risk management in supply chains. The complexity of risk management issues affecting all supply chain stakeholders and the universality of supply chain concepts make it necessary to define the research scope. This includes defining "logistics risk" and establishing parameters for analyzing logistics risks within the context of supply chain management. Theorizing and practicing better logistics risk management relies on enhancing contemporary company logistics systems. Specifically, when designing efficient logistics systems and considering the risk management cycle, it is necessary to solve the following tasks:

• Enhancing approaches to logistics risk identification, which includes recognizing risk occurrences, determining risk causes and origins, and analyzing risk outcomes.

• Working to define and establish the boundaries of logistics processes through the development of industrial and functional reference models, strategies for designing logistics systems, and the specification of logistics processes themselves.

The creation of better methods for logistics control systems and better methods for benchmarking logistics systems and risk management functions are two areas that deserve improvement. The relationship between these tasks is demonstrated in Figure 5.

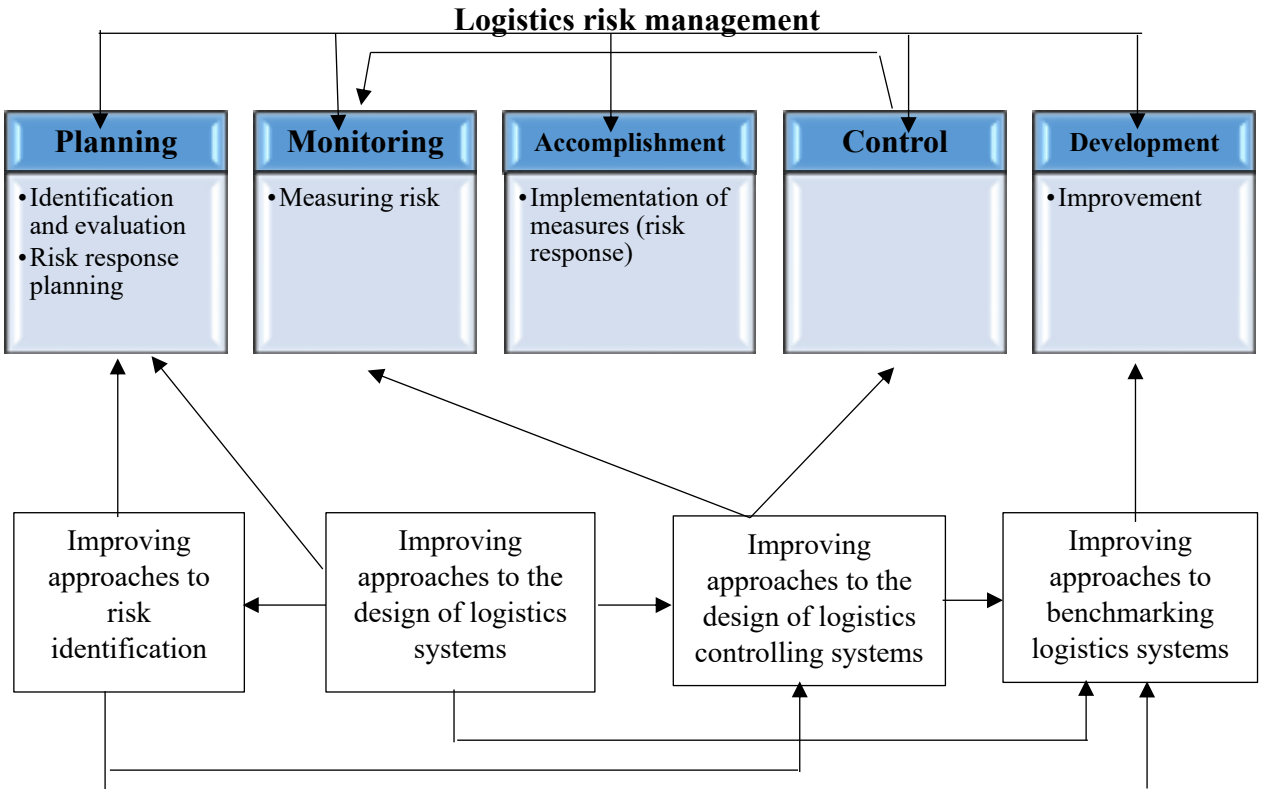

Figure 5.- Main directions of development of logistics risk management. used source [19]

Supply chain security is of the utmost importance for commercial businesses, governments, and national security agencies. "All global economies are now intricately interconnected via global supply chains – networks of companies dispersed worldwide that design, produce, and distribute goods and services," say researchers from the U.S. Potomac Institute for Policy Studies. Supply chains are essential to the building of critical infrastructure and systems that ensure the safety of our nation. Many parties, including the general population, businesses, the federal government, and the military, rely on them. Given that the United States does not have full control over the whole supply chain, the decentralized structure implies that security breaches and threats to the global supply chain pose a threat to American national security and the economy. In order to study important matters related to supply chain security, the Potomac Institute for Policy Studies founded the VITAL Center in 2017.The main points that VITAL center specialists pay attention to in their work are shown in Figure 6

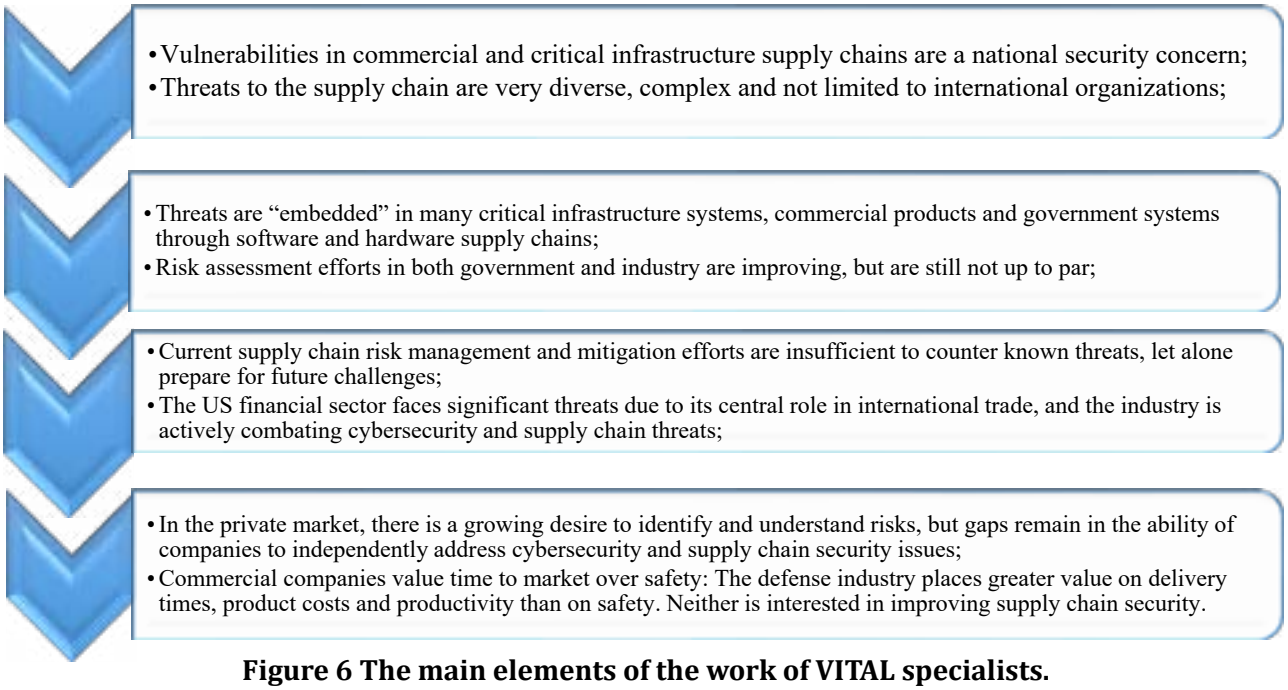

Figure 6 The main elements of the work of VITAL specialists.

[compiled by the authors]

Working with a 3PL provider can also help businesses find vulnerabilities and improve their supply chain.

Examples of supply chain security activities are presented in Figure 7.

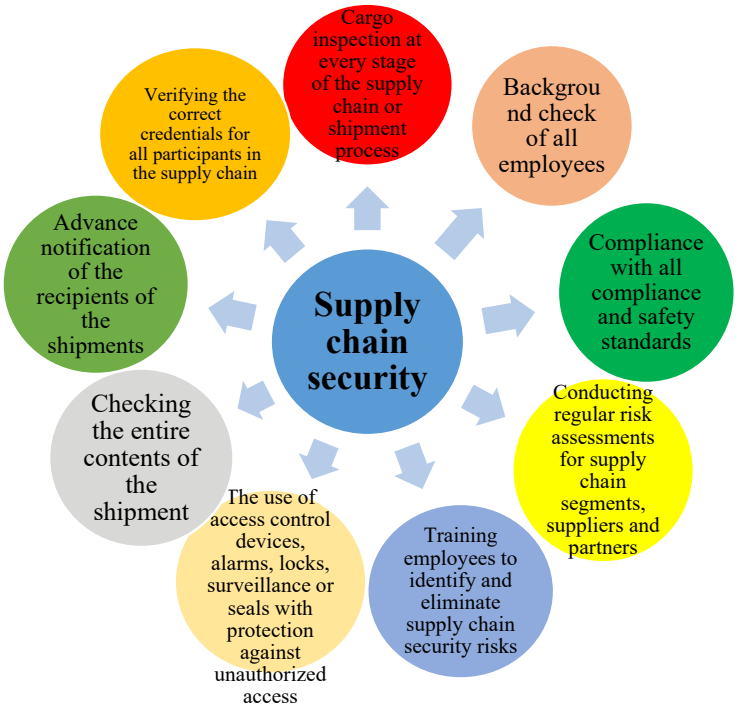

Figure 7 Examples of supply chain security activities

[compiled by the authors].

The representation of processes' current and future states requires the involvement of process owners. Setting reasonable metrics and performance indicators requires clearly defining roles and responsibilities.

In light of the fact that the digital revolution is presently altering the basic company operations of numerous sectors, it is imperative that firms and their employees have a firm grasp of the economics, technological paradigms, and innovation management tactics of digitally focused corporations.

As part of the process of digitizing business processes, new models for operations and business are developed by preparing for the incorporation and implementation of digital technologies. From a supply chain management perspective, process digitalization is often associated with the Gartner Stage 5 maturity model. One way to make this digital model self-sufficient is to use a process-based approach to supply chain modeling. The prospect for the development of these processes involves the creation of "digital twin" models. Digital supply chain refers to an exact copy of the physical supply chain in digital form, which as stated above is called a digital twin. It is proposed to form and create the following models depending on the existing connections in the enterprise:

1. Supplier model. A place where goods are sold through an intermediary. Lack of information about end clients. Common in the B2B sector.

2. Producer of modular products. The ecosystem driver will collaborate on its platform with this organization. Companies that run loyalty programs are one example.

3. The "Omnichannel" structure. To solve customer concerns, a client-owned business combines frequently related goods and services. Throughout the supply chain, the consumer can interact with any channel and switch between them with ease.

4. Model of Ecosystem Drivers. a business that owns the customer and all related data and runs a digital platform. Ecosystem drivers derive value from the information they have about each transaction that takes place in the supply chain. Amazon.com is a prime example.

The global digitalization of supply chains is advancing rapidly; nonetheless, Gartner reports that 70% of enterprises remain at maturity stages 2 and 3. This indicates that 20-30% of prominent organizations are at stage 4 or higher. They surpass competitors due to their ability to provide expedited services at a reduced expense.

Digital transformation of the supply chain frequently causes disturbances during the operating phase, although it ultimately safeguards against more significant disruptions in the long term.An analysis of sample survey data on transport and warehousing firms revealed that the availability of computers and Internet connection in this industry is high, at 83.2% and 81.8%, respectively. The utilization of digital technologies was seen to be minimal (cloud - 1.2%, Big Data - 0.8%, robots - 0.3%).Organizations mostly utilize electronic bills, internet portals, and information system resources. It is imperative to establish mechanisms for the integration of digital technologies into the nation's transport and logistics sector that are advantageous for both the government and the private sector. Particularly crucial is the implementation of electronic document management in cargo transportation processes, the enhancement of supply chain transparency, the automation of loading and unloading operations in warehouses, transport and logistics centers, and terminals, along with other digitalization initiatives.

Additionally, to ascertain particular issues and mechanisms regarding the digital transformation of business processes in logistics service provision in Kazakhstan, it is essential to undertake an empirical study involving market representatives, government entities, and both

international and local logistics providers. The objective of this study is to gather empirical data to identify the primary challenges associated with the utilization of digital technologies in logistics service supply and to formulate recommendations for stakeholders.

To calculate losses from supply chain disruption, we will examine an enterprise in Almaty that receives parts from a warehouse in Shenzhen, China. The supply chain operates on a Just-in-Time principle with no buffer inventory. Following a fire that destroyed the warehouse, parts deliveries were delayed by 14 days. This force majeure event resulted in a 10-day production shutdown at the enterprise. Consequently, 1,200 units of equipment failed to be shipped. The company incurred not only financial losses but also reputational damage. The loss calculation is presented in the following table:

Table 3 – Loss Calculation

Loss item	Formula	Amount (₸)
1. Lost profits	1 200 units × 12 000₸ margins	14 400 000₸
2. Contractual penalties	3 agreements × 2 000 000₸	6 000 000₸
3. Company downtime	10 days × 50 human × 15 000₸/ day	7 500 000₸
4. Reputational losses	Conditional assessment	3 000 000₸
Total		30 900 000₸
Note: compiled by the authors		

This case study illustrates how a single point of failure in the supply chain can result not merely in supply chain disruption but in complete business cessation, financial losses surpassing 30 million tenge, and reputational damage. Effective logistics risk management necessitates comprehensive vulnerability assessment and strategic contingency planning.

Discussion

The digital transformation of logistics is becoming a key driver of sustainable development both globally and within national economies. Kazakhstan, located at the crossroads of Eurasian transport corridors, plays a strategic role in regional logistics. Supply chain risk management requires a shift from traditional approaches to digital solutions, particularly amid growing geopolitical and climate instability. At the current stage of logistics digitalization, the main drivers transforming logistics risk management include: growth in cross-border trade (China, EAEU, Europe); integration of initiatives such as Digital Kazakhstan, Smart Bridge, and Astana Hub; rise of e-commerce and demand for real-time monitoring; adoption of digital CMRs, blockchain, and platform-based solutions.

A scenario-based approach to digitalizing risk management is proposed.

Table 4 – Digital risk management solutions

Type of risk	Example	Digital solutions
Geopolitical	Closing borders	Routing platforms, multi-vector chains

Climate	Drought in the Caspian Sea	IoT-sensors, predictive analytics
Cyber risks	Attacks on WMS	Blockchain and Cyber insurance
Operational	Transport failure	SCADA, digital telematics
Reputational	Delivery disruption	CRM, e-communication with the client
Note: compiled by the authors		

Summarizing the results obtained in the article, based on the analysis, a scenario approach to digitalization of supply chain risk management is proposed.

The scenario-based approach to digitalization of risk management involves the following steps:

1. Digital integration: 90% of companies are implementing digital logistics and monitoring platforms; all customs and transport operations are via the Smart Bridge API; artificial intelligence and blockchain are integrated into 70% of export chains; Kazakhstan is becoming the logistics IT hub of Central Asia.

2. Step–by-step transformation: the introduction of digitalization mainly in the public sector and in large carriers; small and medium-sized businesses are integrating slowly - only 30-40% of companies use automated WMS; reducing the number of serious incidents by 25% due to digital monitoring.

3. Technological gap: lack of integration between public and private platforms; the share of digital solutions is less than 20%; loss of transit attractiveness compared to Azerbaijan and Uzbekistan; increase in incidents by 15% due to inconsistencies in logistics systems.

In the industry aspect, the scenario approach can be summarized as follows:

– Railway industry: SCADA and telemetry;

– Container transportation: digital document management and GPS;

– E-commerce: end-to-end monitoring of orders

– Agricultural sector: IoT sensors in warehouses and trucks.

The key indicators of digitalization may be the following:

– The level of digitalization of companies (100%)

– Average response time to disruptions: delivery delay – 2-6 hours, cyber incident – 15 minutes – 2 hours, transport breakdown – 1-3 hours, natural disaster – 12-24 hours, border closure – 24-48 hours, production shutdown – 6-12 hours

– The number of participants in the chains integrated into the digital ecosystem of Smart Logistics is 60-80%;

– The average number of critical failures in the supply chain per year: in industry – 1-2, agricultural chains – 1-3, small and medium-sized businesses - 3-6.

Logistics theorists frequently refer to recent advances in risk management when talking about potential dangers in the field. These dangers are typically economic in nature and pertain to specific types of businesses or parts of logistics systems, such as logistics service providers, suppliers, customers, manufacturing and trading companies, production and logistics infrastructure facilities, and divisions.

Issues with information distortion, counterparties' decisions to alter the contract terms (e.g., increase prices), contract termination, consumer substitution, and parties involved in the distribution or supply process violating delivery conditions are all considered coordination risks in supply chains, according to some researchers. These concern the relationships between the

various departments inside the organization, as well as with suppliers, customers, and other counterparties, and aim to maximize the profit for everyone concerned. Furthermore, the identified "innovation risks" are noted. concerns associated with the whole chain of interactions between the target firm and its suppliers and consumers in order to ascertain feasible strategies for the creation of novel offerings and the assurance of revenue. Included in this category are the risks associated with selecting a market or market strategy, introducing new technology, and the production of main products and associated logistical support, which includes new competitive advantages in management techniques, operational technologies, and costs.

Conclusion

The major responsibilities of risk management for organizations in Kazakhstan involve the identification and evaluation of hazards. Getting this problem fixed is crucial for the success of everything that comes after it: risk assessment, monitoring, risk response, and oversight. Business risk management can be more effective with a solid scientific and methodological foundation, including well-established taxonomy and vocabulary and ways to identify risk's sources and impacts. The case of Kazakhstan Temir Zholy illustrates that risk management in the railway sector necessitates a comprehensive strategy, encompassing the cultivation of a safety culture, technological integration, safety audits, and human training. The emergence of advanced digital technologies, including IoT and data analytics, enables railway firms to enhance risk management and optimize the safety and efficiency of their operations.

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Contribution of the authors:

Bekmetova Aruna – approval of the final version of the list of references, data collection, article design, preparation of tables and drawings.

Koshkina Olga – conceptual foundations of the study, making a critical review of the structure of the article, processing empirical data, interpreting the results of the study, discussing the results.

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Цифрлық экономикадағы жеткізу тізбегіндегі логистикалық тәуекелдерді басқарудың заманауи мәселелері

Аңдатпа. Бұл зерттеу цифрлық экономиканың динамикасына назар аудара отырып, жеткізу тізбегіндегі логистикалық тәуекелдерді басқаруүрдісіне арналған. Кіріспеде зерттеу кең ауқымда қарастырылады, оның мақсаттары мен міндеттері, даму әдістері мен перспективалары қарастырылады. Зерттеу жеткізу тізбегіндегі логистикалық тәуекелдерді басқарудың заманауи мәселелерін зерттеу мақсатында цифрлық экономиканың қарқынды дамуы тұрғысынан мәселені қарастырады. Зерттеу сандық интеграцияланған жеткізу тізбегіндегі туындайтын логистикалық тәуекелдердің күрделі сипатын нақтылау үшін статистикалық талдау, тақырыптық зерттеулер және сауалнамалар сияқты әртүрлі тәсілдерді қолданады. Зерттеудің негізгі тұжырымдары цифрлық жеткізілім тізбегінде туындайтын қиындықтар мен туындайтын осалдықтарға шоғырланады және осы контексте логистикалық тәуекелдердің динамикалық сипатына жарық түсіреді. Зерттеу нәтижелерін жалпылау негізінде қазіргі цифрлық жеткізу тізбегіндегі логистикалық тәуекелдерді тиімді басқару үшін адаптивті және тұрақты стратегиялардың жоғары маңыздылығын көрсететін негізгі түсіндірулер мен түсініктер ұсынылады. Бұл мақаланың мақсаты – цифрлық экономикадағы логистикалық тәуекелдерді басқару бойынша зерттеулердің ауқымы мен маңыздылығына қысқаша шолу жасай отырып, зерттеудің мәнін баяндау.

Түйін сөздер: логистикалық тәуекел, жеткізу тізбегінің тәуекелдері, тәуекелдерді жіктеу, тәуекелдерді бағалау, тәуекелдерді басқару жүйесі.

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Современные проблемы управления логистическими рисками в цепочке поставок в цифровой экономике

Аннотация. Это исследование посвящено управлению логистическими рисками в цепочках поставок с акцентом на динамику цифровой экономики. Во введении исследование рассматривается в широком контексте, освещаются его цели и задачи, а также методы и перспективы развития. Исследование рассматривает проблему в контексте динамичного развития цифровой экономики с целью изучения современных проблем управления логистическими рисками в цепочках поставок. В исследовании используются различные подходы, такие как статистический анализ, тематические исследования и опросы, чтобы прояснить сложную природу логистических рисков в рамках цифровых интегрированных цепочек поставок. Основные выводы исследования сосредоточены на сложностях и потенциальных уязвимостях, возникающих в цепочках поставок, управляемых цифровыми технологиями, и проливают свет на динамичный характер логистических рисков в этом контексте. На основе обобщения результатов исследования будут представлены ключевые интерпретации и инсайты, подчеркивающие критическую важность адаптивных и устойчивых стратегий для эффективного управления логистическими рисками в

современных цифровых цепочках поставок. Цель данной статьи – изложить суть исследования, предлагая краткий обзор масштабов и значимости исследований по управлению логистическими рисками в цифровой экономике.

Ключевые слова: логистический риск, риски цепочки поставок, классификация рисков, оценка рисков, система управления рисками.

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