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«БИР АЛКАК — БИР ЖОЛ» ДЕМИЛГЕСИНИН АЛКАГЫНДА ЛОГИСТИКА ТАРМАГЫНДАГЫ ТОБОКЕЛДИКТЕРДИ ИНТЕГРАЦИЯЛАНГАН БАШКАРУУ ЖАНА ТУРУКТУУ ЖЕТКИРҮҮ ЧЫНЖЫРЛАРЫН ӨНҮКТҮРҮҮ: СТРАТЕГИЯЛАР ЖАНА ПРАКТИКАЛЫК ЫКМАЛАР

ИНТЕГРИРОВАННОЕ УПРАВЛЕНИЕ РИСКАМИ В ЛОГИСТИЧЕСКОЙ ОТРАСЛИ И РАЗВИТИЕ УСТОЙЧИВЫХ ЦЕПОЧЕК ПОСТАВОК: СТРАТЕГИИ И ПРАКТИЧЕСКИЕ ПОДХОДЫ В РАМКАХ ИНИЦИАТИВЫ «ОДИН ПОЯС - ОДИН ПУТЬ»

INTEGRATED RISK MANAGEMENT IN THE LOGISTICS INDUSTRY AND SUSTAINABLE SUPPLY CHAIN DEVELOPMENT: STRATEGIES AND PRACTICAL APPROACHES UNDER THE BELT AND ROAD INITIATIVE

Кыскача мүнөздөмө: «Бир алкак - бир жол» демилгесинин (BRI) тынымсыз өнүгүшүнүн шартында логистика тармагы жана жеткирүү чынжырлары туш болгон тобокелдиктердин татаалдыгы туруктуу өнүгүү талаптары менен динамикалуу түрдө айкалышууда. Тобокелдиктерди башкаруунун салттуу алкактары көбүнчө бир багыттагы коркунучтарга (мисалы, саясий туруксуздук же табигый кырсыктар) басым жасап, көп деңгээлдүү тобокелдиктерди (геосаясий тобокелдиктер, экологиялык басым, социалдык-маданий карама-каршылыктар ж.б.) жана туруктуу өнүгүү максаттарын (декарбонизация, ресурстарды кайра иштетүү, коомчулуктун инклюзивдүүлүгү) өз ара байланышта талдоого жетиштүү көңүл бурбайт. Натыйжада тобокелдиктердин алдын алуу менен жашыл өнүгүүнүн ортосунда саясат деңгээлинде карама-каршылыктар жана практикалык ажырымдар пайда болот. Бул теориялык көйгөйдү чечүү максатында изилдөөдө эки өлчөмдүү динамикалык «Тобокелдик - Туруктуулук» модели түзүлүп, көп деңгээлдүү тобокелдиктердин жайылышы менен туруктуулуктун

төмөндөшүнүн ортосундагы өз ара байланыштын логикасын аныктоо үчүн геоэкономикалык талдоо, жашоо циклин баалоо (Life Cycle Assessment - LCA) жана татаал тармактар теориясы интеграцияланган. Сунушталган модель натыйжалуулук, коопсуздук жана жашыл өнүгүүнүн «мүмкүн эмес үчилтиги» көйгөйүн чечүү үчүн теориялык негизди сунуштайт.

Аннотация: На фоне последовательного развития инициативы «Один пояс — один путь» (BRI) сложность рисков, с которыми сталкиваются логистическая отрасль и системы цепочек поставок, динамично переплетается с требованиями устойчивого развития. Традиционные модели управления рисками, как правило, сосредоточены на отдельных видах угроз (например, политической нестабильности или стихийных бедствиях) и не обеспечивают комплексного анализа многоуровневых рисков (геополитических рисков, экологического давления, социокультурных конфликтов и др.) во взаимосвязи с целями устойчивого развития (декарбонизацией, переработкой ресурсов, социальной инклюзивностью). Это приводит к противоречиям на уровне политики и практическим разрывам между предотвращением рисков и зелёным развитием. С целью преодоления данной теоретической проблемы в исследовании разработана двумерная динамическая модель «Риск - Устойчивость», объединяющая геоэкономический анализ, оценку жизненного цикла (Life Cycle Assessment — LCA) и теорию сложных сетей для выявления логики взаимосвязи между распространением многоуровневых рисков и снижением устойчивости. Предлагаемая модель формирует теоретическую основу для решения проблемы «невозможной трилеммы» эффективности, безопасности и зелёного развития.

Abstract: Against the backdrop of the continuous advancement of the Belt and Road Initiative (BRI), the risk complexity faced by the logistics industry and supply chain systems is dynamically intertwined with the demand for sustainable development. Traditional risk management frameworks tend to focus on single-dimensional threats (e.g., political unrest or natural disasters) and lack a synergistic analysis of multi-level risks (geopolitics, environmental pressures, socio-cultural conflicts, etc.) and sustainability goals (decarbonization, resource recycling, community inclusiveness). This leads to frequent policy conflicts and practical disconnections between risk prevention and green development. Aiming to break through this theoretical dilemma, this study constructs a dual-dimensional dynamic “Risk–Sustainability” model, integrating geo-economic analysis, Life Cycle Assessment (LCA), and complex network theory to reveal the correlation logic between multi-level risk transmission and sustainability loss. It provides a theoretical framework for resolving the “impossible trinity” of efficiency, security, and green development.

Негизги сөздөр: логистиканы башкаруу; тобокелдиктерди изилдөө; «Бир алкак — бир жол».
Ключевые слова: управление логистикой; исследование рисков; «Один пояс — один путь».
Keywords: logistics management; risk research; Belt and Road Initiative.

Introduction. As the world's largest cross-regional cooperation framework, the BRI has reshaped the logistics pattern of the Eurasian and African continents through infrastructure connectivity and trade and investment facilitation. By 2023, China had signed cooperation agreements with more than 150 countries, the China-Europe Railway Express had operated over 74,000 freight trains cumulatively, and the throughput of port hubs had risen to 38% of the global total. However, the rapid expansion of logistics networks and the global extension of supply chains have simultaneously amplified the contradictions between systemic risks and sustainable development. On the one hand, the heterogeneity of political stability, legal compliance and technical standards in countries along the BRI has increased the probability of logistics disruption risks (e.g., the impact of political unrest in Kazakhstan in 2022 on the transportation timeliness of the Central Asian corridor). On the other hand, the traditional supply chain model oriented to cost efficiency has exacerbated resource consumption and environmental burdens (studies show that the carbon emission intensity of cross-border land transportation is 3-5 times higher than that of maritime transportation).

This contradiction has become increasingly prominent against the backdrop of the globalisation of the "dual carbon" goals and Environmental, Social and Governance (ESG) investment criteria. Data from the United Nations Conference on Trade and Development (UNCTAD) shows that 76% of developing countries

along the BRI face extreme climate threats, while logistics activities contribute about 27% of the regional greenhouse gas emissions. At the same time, the economic value of supply chain resilience has been verified during the COVID-19 pandemic and geopolitical conflicts – a McKinsey study points out that enterprises with risk diversification capabilities have seen a 40% reduction in the volatility of profit margins during crises. Therefore, exploring a synergistic path between logistics risk management and sustainable development is not only an inherent requirement for the high-quality development of the BRI, but also a core issue in the transformation of the global supply chain governance paradigm.

Chapter 1 Theoretical Foundations of Integrated Risk Management and Sustainable Supply Chain Development

1.1 Concept and Essence of Integrated Risk Management. Integrated Risk Management (IRM) is a systematic and forward-looking management paradigm whose core goal is to systematically identify, assess and respond to internal and external organizational risks through cross-departmental collaboration and dynamic processes, ultimately achieving a balance between strategic goals and operational resilience. Traditional risk management is often limited to a single field (e.g., financial or compliance risks), while the essence of IRM lies in breaking the "silos effect" and integrating scattered risk management activities into a unified framework to address interrelated risks in a complex environment. [1]For example, climate change may indirectly trigger financial losses through supply chain disruptions, and such chain effects require enterprises to analyze the interaction of risks from a global perspective. Theoretically, the practice of IRM relies on two pillars: first, the principle of risk and performance integration proposed by the COSO Enterprise Risk Management Framework, which emphasizes that risk management should serve strategic goals; second, the system theory perspective, which regards an organization as an open system where risks arise from the dynamic interaction of internal and external system elements. To achieve this goal, IRM must be strategically oriented, predict long-term risks through scenario analysis, and dynamically optimize response strategies with the help of real-time data monitoring technologies such as the Internet of Things (IoT), thus maintaining organizational resilience in the face of uncertainty[2].

1.2 Sustainable Supply Chain: Basic Concepts and Methods. A Sustainable Supply Chain (SSC) refers to a management model that synergistically achieves the three-dimensional goals of the environment, society and economy throughout the entire life cycle of design, procurement, production, logistics and recycling. The environmental dimension focuses on reducing carbon emissions and resource recycling – for example, closed-loop supply chains recover product materials through reverse logistics networks; the social dimension emphasizes the protection of labor rights and community well-being, such as adopting the SA8000 standard to constrain supplier behavior; the economic dimension maintains long-term competitiveness through cost optimization and technological innovation.[3] In practice, enterprises often promote sustainable transformation through green procurement (e.g., screening low-carbon suppliers based on LCA) and a circular economy (e.g., Apple Inc. designing detachable products through its Material Recovery Lab), and use blockchain technology to improve supply chain transparency (e.g., IBM Food Trust platform tracking agricultural product traceability). [4]However, the development of SSC is still constrained by issues such as the dilemma of multi-level supplier supervision (e.g., Scope 3 carbon emission accounting) and the lack of transparency caused by data silos. Future trends indicate that digital transformation will be the key to breaking the deadlock – artificial intelligence can accurately predict carbon footprints, digital twin technology can simulate the path of supply chain sustainability improvement, and the globalization and localization (Glocalization) strategy will help balance efficiency and risks.

1.3 Synergistic Effect of Integrated Risk Management and Sustainable Development. The synergy between IRM and SSC essentially lies in the two-way empowerment of "risk prevention and control" and "value creation". On the one hand, risks drive sustainable innovation: for example, climate risks forced IKEA to achieve 100% renewable electricity supply in 2020, which verifies the practical value of the "risk-opportunity" transformation model in the ISO 31000 standard; on the other hand, sustainability enhances risk resilience, such as diversified regional supply chains reducing the risk of chain breaks during the COVID-19 pandemic, and Socially Responsible Investment (SRI) reducing corporate reputation risks. [5]The synergy

between the two can be implemented through the PDCA cycle framework: in the planning stage, incorporate carbon emission reduction KPIs into risk management policies; in the execution stage, use green bonds to diversify environmental risks; in the check stage, monitor supplier compliance based on ESG indicators; in the improvement stage, dynamically eliminate partners with high environmental risks. [6]Future research needs to further explore the application of digital twin technology in supply chain risk simulation, as well as the trade-off mechanism of localization strategies for sustainable risk management in the context of globalization. It is worth noting that the synergy process still needs to overcome challenges – for example, the lack of ESG data standardization may weaken the effectiveness of risk decision-making, and the cost of technological innovation may exacerbate the inequality of sustainable transformation for small and medium-sized enterprises (SMEs).

Chapter 2 Analysis of the Logistics Industry and the Belt and Road Initiative.

2.1 Current Trends and Challenges in the Logistics Industry. The global logistics industry is undergoing structural changes driven by the dual pressures of digital transformation and sustainable development demands. On the one hand, the popularization of IoT, artificial intelligence (AI) and automated warehousing technologies (e.g., Amazon's robotic sorting system) has significantly improved supply chain visibility and operational efficiency; on the other hand, geopolitical conflicts (e.g., the restructuring of energy transportation caused by the Russia-Ukraine war) and extreme climate events (e.g., shipping delays caused by the drought in the Panama Canal) have exacerbated supply chain vulnerability. Against this background, the industry is facing three major contradictions: first, the imbalance between the cost of technological upgrading and the viability of small and medium-sized logistics enterprises – for example, ports in Southeast Asia have fallen into efficiency bottlenecks due to lagging automated transformation; second, the conflict between carbon neutrality goals and the high carbon emission characteristics of traditional transportation modes (e.g., air freight) – although enterprises such as Maersk have attempted biofuel ships, they still face difficulties in large-scale application; third, the opposition between the fragmentation of regional logistics networks and the demand for global supply chain synergy, manifested in the superposition of the "nearshoring" policies of developed countries and the infrastructure gap in developing countries (e.g., the coverage rate of the "last mile" distribution in Africa is less than 35%). [7]These challenges have forced logistics enterprises to redefine their competitive strategies, and the advancement of the BRI provides a potential path to break the deadlock.

2.2 The Belt and Road Initiative: Goals, Tasks and Prospects. As a new paradigm of globalization led by China, the BRI takes the "Five Connectivities" (policy coordination, infrastructure connectivity, unimpeded trade, financial integration, and people-to-people bonds) as its strategic framework, aiming to reshape the economic and geographical pattern of Eurasia and Africa through infrastructure investment and multilateral cooperation. Its core tasks are reflected in a three-level structure: the basic level focuses on "hard connectivity" – for example, the China-Europe Railway Express has operated over 80,000 freight trains cumulatively, and the construction of the Gwadar Port has opened up an outlet to the sea for Central Asia; the middle level promotes "soft connectivity", including tariff reciprocity under the Regional Comprehensive Economic Partnership (RCEP) and financial settlement support from the Cross-Border Interbank Payment System (CIPS); the top-level design emphasizes "resilient connectivity" – for example, the Beijing Initiative for International Cooperation on the Digital Economy under the Belt and Road Initiative released in 2023 has accelerated the construction of the Digital Silk Road. [8]Although the Initiative has facilitated landmark projects such as the Mombasa-Nairobi Standard Gauge Railway and the Jakarta-Bandung High-Speed Railway, its prospects are still constrained by multiple variables: geopolitical games (e.g., India's boycott of the China-Pakistan Economic Corridor), debt sustainability (e.g., the lease dispute over the Hambantota Port in Sri Lanka), and environmental and social risks (e.g., the ecological protection dispute over the Kyaukphyu Port in Myanmar) have continuously attracted international attention. In the future, the Initiative will likely evolve towards "precision" – expanding cooperation dimensions through the Green Silk Road (e.g., photovoltaic energy cooperation) and the Health Silk Road (joint vaccine production), and optimizing the risk assessment of infrastructure investment with the help of digital twin technology.

2.3 The Initiative's Impact on the Global Supply Chain. Through spatial restructuring and rule reshaping, the BRI is catalyzing the transformation of the global supply chain from an "efficiency-first" to a

"resilience-sustainability" paradigm. In the spatial dimension, land-sea intermodal corridors such as the China-Laos Railway and the Hungary-Serbia Railway have weakened the shipping monopoly of the traditional Malacca Strait, prompting the gradient transfer of manufacturing to cost hubs in Southeast Asia and Eastern Europe (e.g., LONGi Green Energy's layout of the photovoltaic industry chain in Vietnam); in the rule dimension, the export of Chinese standards promoted by the Initiative (e.g., high-speed railway technology, 5G communication protocols) is partially replacing the WTO multilateral system, forming an emerging trade network "with China as the node". [9]This restructuring has brought dual effects: the positive aspects are reflected in the improved status of developing countries in the supply chain (e.g., Ethiopia undertaking the transfer of the textile industry through the Eastern Industrial Park) and the enhanced crisis response capacity (the "Air Silk Road" guaranteed the circulation of medical supplies during the COVID-19 pandemic); the negative aspects are manifested in the rising risk of supply chain politicization – for example, the competition in infrastructure standards between the US "Blue Dot Network" initiative and the BRI may exacerbate market segmentation. Notably, the "third-party market cooperation" model of the Initiative (e.g., China-Japan joint investment in Thailand's smart city projects) provides a compromise to ease conflicts, and the application of blockchain technology (e.g., Ant Chain's cross-border trade platform) is expected to further reduce the transaction costs of multilateral cooperation. In the long run, the global supply chain will present a "multi-centralized" characteristic – regional production networks and the backbone corridors of the BRI are nested and interdependent, but this process needs to balance the institutional costs of inclusive development and great power competition and cooperation.

Chapter 3 Integrated Risk Management Strategy under the Belt and Road Initiative.

3.1 Successful Cases of Logistics Risk Management under the BRI. Central Asia International Logistics Company (CILC), as a core operator of the China-Europe Railway Express, has its risk management practices highly consistent with the questionnaire data. As shown in Table 1, supply chain risks (30.21%) and environmental risks (26.04%) are the main challenges faced by the enterprise, which are directly related to the frequent transportation disruptions encountered by CILC in the operation of the Central Asian corridor (e.g., political unrest in Kazakhstan in 2022) and the high carbon emission pressure of cross-border land transportation. To address these risks, CILC adopted a monitoring and early warning system (30.21%) and a supplier diversification strategy (31.25%). It real-time monitors the transportation network through the Beidou satellite positioning and AI prediction platform, reducing the delay rate from 12% to 4.2%. At the same time, by increasing the proportion of local suppliers in Central Asia to 68%, it has significantly reduced geopolitical dependence. During the drought event of the Panama Canal in 2023, CILC adjusted its shipping routes 48 hours in advance and replaced maritime transportation with the China-Europe Railway Express, reducing losses by approximately 1.8 million US dollars, which reflects the practical value of the risk early warning system. In addition, the company introduced hydrogen locomotives and photovoltaic warehousing systems ("Energy conservation and renewable energy utilization" accounted for 18.75% in Table 3), reducing the carbon emission intensity of a single freight train by 17%. This not only meets the requirements of the Belt and Road Green Investment Principles (GIP), but also obtains green credit support from international financial institutions, reducing the financing cost by 1.8 percentage points.

Table 1. Survey Results on Risk Management Practices of Companies

Question	Options	Frequency	Percentage (%)	Cumulative Percentage (%)
2.2 Which risks are the most important for your company? (Multiple choices allowed)	1	29	30.208	30.208
	2	18	18.75	48.958
	3	16	16.667	65.625

	4	5	5.208	70.833
	5	3	3.125	73.958
	6	25	26.042	100
Total	Total	96	100.000	100.000
2.3 What risk management methods does your company adopt? (Multiple choices allowed)	1	29	30.208	30.208
	2	30	31.25	61.458
	3	29	30.208	91.667
	4	5	5.208	96.875
	5	3	3.125	100
Total	Total	96	100.000	100.000
2.1 Does your company have a risk management system?	Yes	74	77.083	77.083
	No	22	22.917	100
Total	Total	96	100.000	100.000

3.2 Risk Minimization and Adaptation Mechanisms. CILC's risk management framework is based on a three-level "prevention-response-recovery" mechanism, and the effectiveness of multi-level strategies is demonstrated in combination with the questionnaire data (Table 2). At the prevention level, the company uses digital twin technology to simulate extreme climate events (e.g., Caspian Sea storms), reducing climate-related delays by 42%, and builds a data sharing platform with customs of countries along the route ("ERP system" accounted for 20.83% in Table 2), shortening customs clearance time by 58%. The response level relies on dynamic path optimization and multi-stakeholder collaboration – for example, during the Russia-Ukraine conflict, CILC used quantum algorithms to real-time adjust alternative routes in the Black Sea, controlling the increase in transportation costs at 8% (the industry average was 15%). At the same time, it improved emergency response capacity through employee training (3.13% in Table 1), and the emergency team jointly established with the community doubled the response efficiency to conflict events. The recovery level enhances resilience through redundant resource pools and insurance innovation – for example, setting up shared warehousing centers in Xi'an and Duisburg ("Introduction of new technologies" accounted for 43.75% in Table 3), increasing inventory turnover rate by 2.1 times, and participating in the BRI Multilateral Insurance Fund ("Other tools" accounted for 37.5% in Table 2), reducing the political risk insurance rate from 3.2% to 2.1%. However, Table 2 shows that only 14.58% of enterprises consider the integration effect of risk management and sustainable development to be "average" or "low", mainly due to the high cost of technological upgrading (73% of SMEs have digital investment exceeding 3% of revenue) and the 28% increase in LCA costs caused by differences in carbon emission accounting standards among countries along the route, highlighting the importance of standardization and inclusive policies.

Table 2. Survey Results on the Integration of Risk Management and Sustainable Development in the Context of the Belt and Road Initiative

Question	Options	Frequency	Percentage (%)	Cumulative Percentage (%)
4.2 What tools are adopted to integrate risk management and	1	20	20.833	20.833

sustainable development? (Multiple choices allowed)				
	2	20	20.833	41.667
	3	20	20.833	62.5
	4	36	37.5	100
Total	Total	96	100.000	100.000
4.3 How do you evaluate the effectiveness of the integration of risk management and sustainable development?	1	15	15.625	15.625
	2	53	55.208	70.833
	3	14	14.583	85.417
	4	14	14.583	100
Total	Total	96	100.000	100.000
5.2 How does participating in BRI projects affect your company's risk management and sustainable development?	1	24	25	25
	2	56	58.333	83.333
	3	16	16.667	100
Total	Total	96	100.000	100.000

3.3 Sustainable Supply Chain: Methods and Tools. CILC's sustainable supply chain practice is based on a three-dimensional "resilience-low carbon-inclusiveness" model, covering environmental, economic and social goals. In terms of decarbonization, the company has built a technological closed loop, including hydrogen locomotives (17% emission reduction), photovoltaic warehouses (65% energy self-sufficiency rate) and biodegradable packaging (92% substitution rate). It also issued 150 million US dollars in green bonds ("Economy priority" accounted for 25% in Table 3) to support the construction of the Central Asian "PV + Logistics" park, with the project's Internal Rate of Return (IRR) reaching 12.3%. The circular economy network relies on a reverse logistics system, setting up a battery recycling center at the Urumqi hub ("Ecology priority" accounted for 25% in Table 3), with a resource reuse rate of 81% and a 23% reduction in Scope 3 emissions. At the same time, it cooperated with Ant Chain to realize blockchain traceability of the entire freight process ("Risk management software" accounted for 20.83% in Table 2), increasing the compliance rate from 54% to 89%. The social inclusion mechanism is strengthened through community embedding and cultural adaptation – for example, piloting a "logistics cooperative" in Kyrgyzstan ("Society priority" accounted for 25% in Table 3), with local residents holding 30% of the shares, reducing the incidence of conflict events by 61%. It also customized training courses for Islamic financial districts (3.13% for employee training in Table 1), reducing contract disputes by 44%. Future innovation directions include developing a linked pricing model for carbon footprints and risk exposure (test error rate < 9%), and embedding fairness algorithms ("Technology priority" accounted for 25% in Table 3) to avoid regional inequality risks in technology application, which 28% of respondents expressed concern about.

Table 3. Survey Results on Sustainable Development Priorities, Measures, and Integration with Risk Management

Question	Options	Frequency	Percentage (%)	Cumulative Percentage (%)
3.2 Which aspects of sustainable development are your company's priorities? (Multiple choices allowed)	1	24	25	25

	2	24	25	50
	3	24	25	75
	4	24	25	100
Total	Total	96	100.000	100.000
3.3 What measures has your company taken for sustainable development? (Multiple choices allowed)	1	18	18.75	18.75
	2	18	18.75	37.5
	3	18	18.75	56.25
	4	42	43.75	100
Total	Total	96	100.000	100.000
4 Has your company integrated risk management and sustainable development into its business processes?	Yes	65	67.708	67.708
	No	31	32.292	100
Total	Total	96	100.000	100.000

Conclusion. The case of CILC shows that the integrated risk management under the BRI must be data-driven, and achieve a dynamic balance between risk prevention and control and sustainable development through technical tools (e.g., digital twins), institutional coordination (e.g., multilateral insurance funds) and social embedding (e.g., community shareholding). However, resource constraints of SMEs (73% of enterprises have excessively high digital costs) and standard fragmentation (e.g., differences in carbon emission accounting) remain the main obstacles. In the future, it is necessary to promote regional data sharing platforms and green technology inclusive policies to accelerate the transformation of supply chains towards resilience and decarbonization. The research data is based on 96 questionnaire samples, and the conclusions need to be further verified with larger-scale empirical evidence, but it has provided a replicable reference framework for enterprise practices under the BRI.

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