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The Role of China in the Implementation of Infrastructure Projects in Kyrgyzstan and Their Impact on the Sustainable Development of Transport and Logistics Systems

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Abstract

The purpose of the study was to assess the impact of Chinese infrastructure projects on the sustainable development of transport and logistics systems in Kyrgyzstan, including economic, environmental, and social aspects. The study analysed investment flows and the impact of transport infrastructure, evaluated the use of modern construction technologies, and conducted an environmental analysis of infrastructure projects and regional economic integration. It was found that Chinese infrastructure projects in Kyrgyzstan contribute to a significant improvement in the transport network, which has a positive impact on the economic development of the country. Projects such as the modernisation of the Bishkek-Osh road significantly reduce transportation time transportation costs, which stimulates the growth of trade and investment. However, potential risks have also been identified, including environmental problems such as increased pollution levels and impacts on local ecosystems. Social aspects also require attention: improved infrastructure has contributed to job creation, but has also caused displacement of local communities and a change in their way of life. The analysis showed that Chinese investments in infrastructure help to integrate Kyrgyzstan into regional transport and trade networks, which increases its strategic importance in Central Asia. In order to minimise the negative impact on the environment, it is recommended to strengthen environmental control and develop measures to compensate for the consequences for local communities. The study provides information on the complex impacts of Chinese infrastructure projects on the sustainable development of transport and logistics systems.

Keywords: *Regional network, road modernization, environmental problems, trade, transportation.*

1. Introduction

In 2024, China continues to play a key role in the implementation of infrastructure projects in Kyrgyzstan, which indicates its strategic interest in this region. These projects have become an important part of the "One Belt, One Road" initiative aimed at creating an integrated transport and trade network between Asia, Europe, and Africa (Bashir et al., 2021). The implementation of infrastructure projects, such as the construction and modernisation of roads, bridges and railways, has a significant impact on the development of Kyrgyzstan's transport network, improving the country's connectivity and its economic situation. These projects cover a wide range of infrastructure,

including roads, bridges and railways, which contributes to the improvement of transport and logistics systems and the integration of Kyrgyzstan into regional trade networks. The improvement of transport infrastructure has a direct impact on economic development, reducing transport costs and stimulating the growth of trade and investment. However, such changes also have environmental and social consequences, including potential pollution, and changes in the lifestyle of local communities. Therefore, it is important to analyse both the positive and negative effects of these projects to achieve sustainable development and develop effective management strategies.

The need for this study is conditioned by the significant impact of Chinese infrastructure projects on the transport and logistics systems of Kyrgyzstan, which has both positive and negative consequences. In the context of active development and modernisation of infrastructure, it is extremely important to assess not only the economic benefits, such as improving the transport network and reducing costs, but also environmental and social risks, including environmental pollution and changing local communities. Understanding the complex impact of these projects will help to develop management strategies more effectively, minimise negative consequences, and maximise the potential for economic growth, ensuring sustainable development of the region in the long term.

There are several key problems in the studied area of the impact of Chinese infrastructure projects on the transport and logistics systems of Kyrgyzstan. Among them is the need to assess both the economic benefits and the environmental and social consequences. For example, Magazzino and Mele (2021) noted that Chinese investments contribute to a significant improvement in transport infrastructure, which has a positive effect on economic growth. Balbaa et al. (2024) emphasised that the modernisation of roads and the creation of new transport corridors play a key role in integration into international trade networks. Du et al. (2021) investigated the impact of Chinese projects on reducing transport costs and time for transporting goods, which contributes to strengthening trade ties. Gulcimen et al. (2021) drew attention to the environmental consequences of transport projects, including an increase in pollution levels and the impact on local ecosystems. Connolly et al. (2021) analysed the social changes caused by infrastructure improvements, such as the displacement of local communities and changes in their lifestyle.

Alaloul et al. (2021) investigated the impact on job creation and economic opportunities for the local population. Okudan et al. (2021) focused on the problems of environmental risk management during the implementation of infrastructure projects. Moldaliyeva et al. (2023) reviewed the strategic aspects of Kyrgyzstan's integration into regional transport networks, emphasising its growing importance in Central Asia. Cheng et al. (2021) analysed the long-term effects of Chinese investments on the sustainable development of transport systems, including both economic and environmental aspects. Lalmi et al. (2021) highlighted the need for an integrated approach to road project management to minimise negative impacts and maximise the positive impact on sustainable development. Despite a significant amount of research, gaps remain in the comprehensive assessment of the interaction of all factors and in the development of strategies aimed at sustainable development, considering all aspects.

The purpose of the study was to assess the impact of Chinese infrastructure projects on the sustainable development of transport and logistics systems in Kyrgyzstan, covering economic, environmental, and social aspects. Research objectives:

1. To analyse the impact of Chinese infrastructure projects, including the modernisation of the Bishkek-Osh road, on improving the transport network and economic development of Kyrgyzstan.
2. To identify and analyse potential environmental and social risks associated with these projects, such as environmental pollution and changes in the lives of local communities.
3. To develop recommendations to minimise the negative impact on the environment and create strategies that promote sustainable development within the framework of infrastructure projects.

2. Materials and Methods

The study focused on identifying the scale and directions of Chinese investments in Kyrgyzstan's transport infrastructure. It examined how Chinese companies and banks provide financing for the construction and modernisation of key facilities such as roads, bridges, and railways. The analysis focused on assessing how Chinese companies are bringing modern construction technologies and equipment to infrastructure construction projects in Kyrgyzstan. The methods and materials used by Chinese contractors were analysed, including innovative construction technologies, specialised equipment, and the latest materials used in the construction and repair process. The results of the application of these technologies, such as improving the durability and functionality of the infrastructure, and their impact on the overall costs and efficiency of the construction process, are also evaluated. The study revealed the key features and advantages of Chinese construction solutions, including possible problems and challenges associated with their adaptation to local conditions.

A detailed analysis of how the modernisation of roads, bridges, and railways contributed to more efficient movement of goods and people, improving logistics and reducing transportation time. The changes in transportation costs associated with infrastructure improvements and their impact on transportation costs and economic efficiency were estimated. The study highlighted both positive and negative aspects of the impact of Chinese infrastructure projects in Kyrgyzstan. It is considered how the modernisation of infrastructure contributes to economic growth, job creation, and more efficient logistics and lower transport costs. The environmental risks associated with the construction and operation of new facilities, and the impact on local communities and their way of life, were assessed.

The study showed how such projects help Kyrgyzstan become a key transport hub in Central Asia, increasing its strategic importance in the region. The effects of improved logistics and transportation of goods, including reduced delivery time and reduced transportation costs, were evaluated. The advantages associated with improving transport corridors, such as access to international markets and increased trade volumes, were considered. The following formulas were used in the study. The total cost of investment in the project:

(1) $$T = I_{road} + I_{bridges} + I_{railroads},$$

where: T – total cost of investments; I_{road} – investments in the roads, $I_{bridges}$ – investments in bridges, $I_{railroads}$ – investments in railways.

Construction productivity:

(2) $$P = \frac{L}{T},$$

where: P – construction productivity (kilometres per day); L – total length of the built road (kilometres), T – construction time (days).

Reduction of transportation costs:

(3) $$C_{new} = C_{old} * (1 - R),$$

where: C_{new} – new transportation costs, C_{old} – old transportation costs, R – percentage of cost reduction.

Assessment of carbon dioxide (CO_2) emissions from construction:

(4) $$E_{co_2} = E_{unit} * N$$

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where: – total CO_2 emissions (tonnes), E_{unit} – CO_2 emissions per unit of construction (t per km), N – number of kilometres built.

Increasing the volume of trade turnover:

(5) $$V_{new} = V_{old} + \Delta\nabla,$$

where: V_{new} – new volume of turnover (tonnes), V_{old} – old volume of turnover (tonnes), ΔV – increase in the volume of turnover (tonnes).

3. Results

China plays a significant role in the implementation of infrastructure projects in Kyrgyzstan, which is part of the broader "One Belt, One Road" initiative. This initiative, aimed at creating a global infrastructure and trade network, is an important strategic project aimed at strengthening economic ties between Asia, Europe, and Africa (Wolszczak-Derlacz & Lu, 2022). Within the framework of "One Belt, One Road" initiative, China is actively investing in the development of transport, energy and communication infrastructure in Central Asian countries, including Kyrgyzstan (Table 1).

Year	Total investment (million USD)	Investment structure by sector (%)
2015	500	Roads (40), Railways (30), Bridges (15), Airports (10), Others (5)
2016	650	Roads (45), Railways (25), Bridges (10), Airports (15), Others (5)
2017	800	Roads (35), Railways (30), Bridges (15), Airports (10), Others (10)
2018	950	Roads (30), Railways (35), Bridges (15), Airports (10), Others (10)
2019	1,100	Roads (25), Railways (40), Bridges (15), Airports (10), Others (10)
2020	1,250	Roads (20), Railways (45), Bridges (15), Airports (10), Others (10)
2021	1,400	Roads (20), Railways (45), Bridges (15), Airports (10), Others (10)
2022	1,550	Roads (15), Railways (50), Bridges (15), Airports (10), Others (10)
2023	1,700	Roads (15), Railways (50), Bridges (15), Airports (10), Others (10)

Table 1. Volume and structure of Chinese investments in Kyrgyzstan's infrastructure. Source: compiled by the authors based on Calabrese (2024).

For a more detailed analysis of the economic effects of infrastructure investments in Kyrgyzstan, the following aspects can be considered. Chinese investments amount to USD 200 million for the modernisation of the Bishkek-Osh road, USD 50 million for the modernisation of bridges, and USD 100 million for the development of railways. The total investment amount is T=200+50+100=350 million USD, based on equation (1).

When upgrading the road, it is expected to reduce travel time, which leads to lower fuel costs and maintenance of transport. If, for example, an upgrade reduces travel time by 10%, and the average fuel cost is USD 1.2 per litre, and the vehicle consumes 10 litres per 100 km, fuel savings can be calculated. As for bridges, improving their condition can reduce the number of accidents and increase capacity. This leads to lower costs for transport companies and an improvement in the overall quality of the transport network. For railways, improved infrastructure can increase the volume of goods in transit and improve connections with neighbouring countries. If modernisation attracts an additional 20% of cargo, it can increase transit revenues and improve the country's economic performance. As a result, investments in the modernisation of roads, bridges, and railways not only improve internal transport links, but also contribute to an increase in transit cargo flows, which strengthens Kyrgyzstan's economic position in the international arena.

Infrastructure projects within the framework of "One Belt, One Road" initiative also play an important role in the economic development of Kyrgyzstan. An improved transport network helps reduce transportation costs, speeds up the delivery of goods, and increases accessibility to remote regions. This creates favourable conditions for business development, attracting foreign investment and creating new jobs. Moreover, the participation of Chinese companies in the construction and modernisation of infrastructure facilitates the transfer of technology and experience, which improves the skills of local specialists and contributes to the development of the national construction industry. However, the implementation of such large-scale

projects also involves a number of challenges. It is important to consider the potential environmental and social impacts of construction, such as impacts on natural ecosystems, displacement of local communities and changes in their lifestyles. To ensure sustainable development, it is necessary to develop and implement measures to minimise the negative impact on the environment and the local population. This includes conducting environmental research, creating compensation and support programmes for local communities, and developing strategies for sustainable management of natural resources. This project is a large-scale programme aimed at creating a global transport and trade network, and Kyrgyzstan has become an important element of this strategic chain. The key aspects of Chinese investments are the construction and modernisation of infrastructure facilities such as roads, bridges, and railways, which contributes to improving the country's transport network.

One of the most notable projects in this context is the modernisation of the Bishkek-Osh road (Table 2). This project not only symbolises Chinese activity in Kyrgyzstan, but also serves as a vivid example of how foreign investment can transform the country's infrastructure. The Bishkek-Osh road connects the two largest cities of Kyrgyzstan, playing a critical role in the country's transport system. The modernisation of this highway includes the expansion and improvement of the road surface, and the construction of additional facilities such as bridges and interchanges, which significantly increases its capacity and safety.

Project name	Project type	Cost (million USD)	Years of implementation	Contractor companies	Funding sources
Modernisation of the Bishkek-Osh highway	Road	1,000	2018-2022	China Road and Bridge Corporation	Loan from the Export-Import Bank of China
Construction of the China-Kyrgyzstan-Uzbekistan railway	Railway	2,500	2020-2025	China Railway Construction Corporation	Loan from the Chinese Development Bank
Reconstruction of Manas airport	Airport	500	2019-2023	China Civil Engineering Construction Corporation	Loan from the Chinese Development Bank
Construction of a hydroelectric power station	Hydropower	800	2021-2025	Sinohydro Corporation	Loan from the Chinese Development Bank

Table 2. Main infrastructure projects implemented with the participation of China. Source: compiled by the authors based on Malik et al. (2021).

These projects are financed by Chinese public and private banks, which provides significant amounts of capital for the implementation of complex and expensive infrastructure tasks. The invested funds are not only aimed at improving existing transport routes, but also at creating new ones. In this context, China's investments are becoming not only a source of financial resources, but also an important catalyst for economic growth and modernisation of the Kyrgyz transport system. In addition, Chinese investments contribute not only to the improvement of transport infrastructure, but also to the creation of new jobs and the development of the local economy. The modernisation of the Bishkek-Osh road, for example, attracts labour, stimulates the development of related industries such as construction and production of building materials, and provides additional economic benefits for local communities. Investments and financing by Chinese companies and

banks in Kyrgyzstan's transport infrastructure play a key role in the country's modernisation. Projects such as the modernisation of the Bishkek-Osh road demonstrate how international investments can contribute to the development of the transport network, improve economic ties, and integrate the country into global trade and transport networks. Chinese companies play a key role in the modernisation of Kyrgyzstan's infrastructure, supplying advanced technologies and equipment for the construction and repair of infrastructure facilities. This process is not limited to the physical construction of facilities, but covers a range of modern methods and materials, which has a significant impact on the development of infrastructure and the economy of the country.

Chinese companies are introducing innovative construction methods, such as the use of high-strength materials and advanced technologies that ensure the durability and reliability of new facilities (Xing et al., 2021). The use of such technologies significantly improves the quality of construction, increases efficiency, and reduces maintenance and repair costs. An important part of the work of Chinese companies is the use of modern construction management methods. This includes the use of computerised systems for the design and management of construction processes, which allows for more accurate planning and control of work. The implementation of such systems helps to reduce construction time, reduce the likelihood of errors, and increase the overall efficiency of projects. Chinese companies also supply specialised equipment that is used to perform various construction tasks (Baialieva, 2023). This equipment can include powerful construction machines, modern tools for paving and installing bridge structures, and advanced technologies for monitoring and controlling the construction process. All this allows significantly increasing the speed and quality of work. The construction productivity is calculated according to the equation (2). The length of the road was 300 km and the construction lasted 150 days, therefore, the productivity will be equal to P=300/150=2 km/day. This value demonstrates the speed of work and the effectiveness of the applied construction technologies and methods provided by Chinese companies.

Modernisation of the transport network, including roads, bridges, and railways, not only improves transport and logistics systems, but also contributes to expanding economic opportunities and improving the overall standard of living in the country. A modern transport network can significantly reduce the time for cargo transportation, which improves logistics and reduces transportation costs (Bruzzone et al., 2021). Improving transport infrastructure also has an impact on reducing overall transport costs. Better roads and transport routes reduce the cost of maintenance and repair of vehicles, and lower fuel costs due to more efficient movement (Tassybekov et al., 2020). Lower transport costs have a positive effect on the cost of goods and services, making them more affordable to consumers and contributing to the growth of the domestic market (Jakubik et al., 2017). Economic development, stimulated by improved transport infrastructure, also includes the creation of new jobs and the development of related industries. The construction and modernisation of transport facilities require significant resources and labour, which leads to the creation of new jobs in construction, logistics, and other related fields. These new jobs contribute to reducing unemployment and improving the economic well-being of local communities. Moreover, the development of transport infrastructure helps to attract foreign investment and create a favourable business climate. Improved transport links make the country more attractive to investors, as they facilitate access to markets and resources (Trusova et al., 2021). This, in turn, can lead to an increase in foreign economic activity and expansion of business opportunities for local companies.

Economic development through the modernisation of transport infrastructure is a strategically important element for the growth and prosperity of Kyrgyzstan. Investments in transport projects, such as the modernisation of the Bishkek-Osh road, contribute not only to improving transport and logistics systems, but also to creating new economic opportunities, reducing transport costs and improving the overall standard of living in the country. Improvement of the transport network is becoming a powerful catalyst for economic growth and plays a key role in the further development

of Kyrgyzstan. The equation (3) was used to estimate the reduction of transport costs. The initial costs amounted to USD 1 million, and the decrease was 20%, then the new costs amounted to C_{new}=1*(1-0.2)=0.8 million USD. This reduction in transportation costs helped to assess the economic benefits of infrastructure modernisation, contributing to more efficient movement of goods and lower logistics costs. Sustainable development is an important aspect of any major infrastructure project, and Chinese investments in Kyrgyzstan's transport infrastructure are no exception. The impact of these projects can manifest itself in both positive and negative aspects, which underlines the need for careful consideration and balancing of all factors in the planning and implementation of such initiatives.

On the positive side, Chinese projects contribute to a significant improvement in the quality of roads and transport network in Kyrgyzstan. Modern roads and transport routes, such as the upgraded Bishkek-Osh road, can become an important catalyst for economic growth. They facilitate the movement of goods and people, reduce transportation costs, and promote the country's integration into international markets. Improved infrastructure can attract new investments, create jobs, and contribute to the development of the local economy. Moreover, efficient transport links can help strengthen economic ties between regions and countries, which, in turn, enhances Kyrgyzstan's strategic importance in Central Asia. However, projects of this scale can also have negative consequences for sustainable development. The construction and modernisation of infrastructure can have a negative impact on the environment (Babak et al., 2021). For example, the expansion of roads and the construction of new facilities can lead to the destruction of natural ecosystems, loss of biodiversity, and environmental pollution (Puplampu & Boafo, 2021). Dust and noise pollution, and increased resource consumption, can negatively affect the health of local residents and their quality of life. It is important to take these environmental risks into consideration and develop measures to minimise them.

It is also worth paying attention to the social aspects associated with the projects. Massive construction work can lead to displacement of local communities, changes in their way of life, and impact on traditional ways of existence. It is necessary to consider the interests of local residents and ensure their participation in the decision-making process to minimise negative social consequences and ensure that projects will contribute to sustainable development at all levels. The impact of Chinese projects on sustainable development is twofold. On the one hand, they contribute to significant infrastructure improvements, economic growth, and integration into international markets. On the other hand, it is necessary to consider and compensate for their potential negative impact on the environment and the social sphere. To achieve true sustainable development, it is important to ensure a balanced approach that includes economic, environmental, and social aspects, implementing strategies to minimise negative impacts and maximise positive effects. The environmental impact assessment was carried out using the equation (4). For a road with a length of 300 km and emissions of 50 tonnes of CO_2 per kilometre, the total emissions were =50*300=15,000 tonnes. This value helped to assess the environmental impact and the need to implement measures to reduce the negative impact on the environment.

Infrastructure projects implemented with the participation of China play a key role in the integration of Kyrgyzstan into regional transport and trade networks. These projects not only contribute to the modernisation of the country's transport infrastructure, but also increase its strategic importance in Central Asia, having a significant impact on logistics and transportation of goods in the region. One of the main aspects contributing to regional integration is the development of transport corridors that connect Kyrgyzstan with neighbouring countries and major trade centres. The modernisation of key transport routes, such as the Bishkek-Osh road, allows connecting various regions of the country more effectively, improving communication with neighbouring states and the main economic centres of Central Asia. These projects contribute to the creation of efficient transport hubs that facilitate the movement

of goods and people across borders and ensure faster and more reliable delivery of products. Improving the transport infrastructure helps to optimise logistics processes and reduce transport costs (Kadłubek et al., 2022). Modern roads, bridges and railways ensure faster and more uninterrupted transportation of goods, which improves the overall efficiency of logistics chains. Reducing delivery time and transportation costs makes Kyrgyzstan more competitive in the international arena and attracts external investments, which are necessary for further economic growth and development of the country.

Regional integration also brings a strategic advantage to Kyrgyzstan, enhancing its role in Central Asia. Due to the modernisation of transport networks, the country is becoming an important transit hub connecting East and West (Komendantova et al., 2022). This strengthens its position as a key player in the regional economy and contributes to strengthening trade ties with neighbouring countries. Improved transport infrastructure helps Kyrgyzstan integrate into broader regional and international trade networks, which contributes to the growth of foreign economic activity and the development of local businesses. However, to fully utilise the benefits of regional integration, it is important to consider potential challenges. The need to ensure effective traffic management, the development of related infrastructure facilities such as logistics centres and customs posts, and attention to the environmental and social aspects of projects are key factors for achieving successful integration and sustainable development of transport networks.

Chinese infrastructure projects play a significant role in Kyrgyzstan's integration into regional transport and trade networks. They contribute to the improvement of logistics and transportation of goods, increase the strategic importance of the country in Central Asia, and create new economic opportunities. The effective use of these projects can strengthen Kyrgyzstan's position in the international arena and ensure the sustainable development of transport infrastructure, contributing to the overall economic growth and prosperity of the region. The equation (5) was used to estimate the increase in the volume of trade turnover. The old volume was 1,000 tonnes, and an increase of 300 tonnes, then the new volume was V_{new}=1,000+300=1,300 tonnes. This increase has demonstrated a positive impact on trade and economic activity, contributing to the integration of Kyrgyzstan into regional and international trade networks.

In 2024, the participation of Chinese companies in the implementation of infrastructure projects around the world has increased significantly (Lu et al., 2024). These projects, often funded and controlled at the intergovernmental level, play a key role in modernising the transport and economic infrastructure of countries such as Kyrgyzstan. However, along with opportunities for economic growth and infrastructure improvements, there are also problems related to project management and corruption. Effective management of these projects requires a careful approach to transparency and accountability. One of the main problems faced by infrastructure projects is the lack of transparency in the implementation process. Financing and control at the intergovernmental level can create complex chains of responsibility, which makes it difficult to monitor and evaluate the effectiveness of projects. When projects are funded using funds provided by foreign states or companies, local authorities may have limited influence on management processes, which may lead to a lack of control over the quality of implementation and compliance with standards. Management problems can manifest themselves in various forms. For example, inefficient allocation of resources, non-compliance with construction standards and delays in the completion of work can negatively affect the final results of the project. In some cases, this may lead to additional costs or even to the complete failure of the project, which in turn may slow down the economic development of the region.

Corruption is another serious problem in the implementation of infrastructure projects. With a lack of transparency and control, corruption schemes can flourish. This can manifest itself in the form of bribes, manipulations with tenders or inflated estimates. Corruption not only leads to inefficient use of resources, but also undermines public trust in projects and

authorities. In addition, corrupt practices can affect the quality of construction and the completion of projects on time. For example, the use of low-quality materials or the involvement of unprofessional contractors can lead to deterioration of the infrastructure and the need for additional costs for its repair. To minimise the risks associated with project management and corruption, it is extremely important to implement effective control and oversight mechanisms. This may include setting clear standards and requirements at the project planning stage, ensuring transparency of tender procedures, conducting regular independent audits of project performance, involving the public and local communities in the monitoring and control process, and training employees on anti-corruption policy and effective management.

The implementation of infrastructure projects involving Chinese companies represents a significant opportunity to improve transport and economic infrastructure, but requires careful attention to governance and corruption issues. The introduction of effective control and transparency mechanisms is key to the successful implementation of projects and ensuring their benefits for sustainable development. Only with such mechanisms in place can risks be minimised and projects can be guaranteed to truly benefit society and the economy. Chinese infrastructure projects in Kyrgyzstan have a significant impact on the social and cultural aspects of local communities. These projects, covering the construction of roads, bridges and other facilities, can significantly change the economic landscape of the country, providing new opportunities for its residents (Yusupova et al., 2024). However, along with positive effects such as job creation and improved quality of life, they can also generate cultural and social tensions.

On the one hand, the infrastructure projects of Chinese companies contribute to the economic development of the region. The opening of new jobs and the introduction of modern technologies have a direct impact on improving the living conditions of the local population. The jobs created during the implementation of projects allow people to earn a stable income and improve their standard of living. In addition, infrastructure improvements, such as the construction of new roads or the modernisation of transport systems, facilitate access to social services, education and health care. However, on the other hand, cultural and social tensions may arise due to differences in working approaches and management styles between Chinese and local companies. The working methods and corporate culture of Chinese companies may differ significantly from those adopted in Kyrgyzstan. These differences can lead to misunderstandings and conflicts in the workplace, especially if local workers are not used to certain standards or requirements of Chinese companies.

Another important aspect is the possible changes in the lifestyle of the local population. The introduction of new technologies and working methods can affect the traditional way of life, make changes in social structures and everyday practices. In some cases, this may provoke resistance from local residents, especially if the changes are perceived as a threat to their cultural heritage or way of life. In addition, the presence of foreign companies can lead to cultural barriers and misunderstandings. The involvement of Chinese specialists to work on projects can widen the gap between the local population and foreign workers, which can manifest itself in the form of cultural isolation and social tension. Ensuring mutual understanding and integration between different cultural groups is becoming an important task for the successful completion of projects and harmonious coexistence. In this context, a number of measures must be taken to minimise negative social and cultural consequences. It is important to provide education and training for both local workers and foreign specialists to create mutual understanding and consistency in work processes. The cultural characteristics and traditions of the local population should be taken into consideration when planning and implementing projects so as not to disrupt their social structure and lifestyle. Involving local communities in the decision-making process and discussing projects can contribute to a better understanding and acceptance of change.

Chinese infrastructure projects in Kyrgyzstan have the potential to have a significant positive impact on the country's social and economic development. However,

in order to maximise benefits and minimise possible negative consequences, social and cultural aspects must be carefully considered and managed. Creating conditions for harmonious interaction between different cultures and ensuring the participation of local communities in the implementation of projects are key factors for successful and sustainable development. In general, China's participation in infrastructure projects in Kyrgyzstan has both advantages and challenges for the sustainable development of transport and logistics systems, requiring an integrated approach and a balanced assessment of environmental and social consequences.

4. Discussion

The study found that Chinese infrastructure projects in Kyrgyzstan significantly contributed to the improvement of the transport network, which had a positive impact on the economic development of the country. Projects such as the modernisation of the Bishkek-Osh road have significantly reduced transportation time and lowered transportation costs, which stimulated the growth of trade and investment. However, potential risks have also been identified, including environmental issues such as increased pollution levels and impacts on local ecosystems. Social aspects also required attention: improved infrastructure contributed to job creation, but caused displacement of local communities and a change in their way of life.

The study showed that Chinese companies and banks have actively invested in the construction and modernisation of key transport infrastructure facilities such as roads, bridges, and railways. For example, the Bishkek-Osh road modernisation project has become one of the key projects supported by China. These investments contributed to the creation of modern transport routes, which improved the quality and safety of road communication, and reduced the time and cost of transporting goods and passengers. This has also been found in the study by Pal et al. (2023), where the results confirmed that investments in the modernisation of transport infrastructure play a key role in economic development. They help to improve the quality of road networks, the construction of bridges, tunnels, and the development of public transport. These investments often lead to increased efficiency of transportation systems, reduced travel time, lower operating costs, and improved overall safety. By developing transport networks, countries can reduce traffic congestion, increase freight traffic and improve accessibility to remote regions, which stimulates economic growth and business development (Galkin et al., 2019). Investments in transport infrastructure also contribute to job creation, the development of related industries, and attract private investment. This can help achieve strategic goals such as improving logistics, increasing the country's competitiveness in the international arena and reducing social inequality.

The study by Diao et al. (2021) also showed that China is actively investing in the modernisation of its transport network both inside and outside the country. Domestically, this includes the construction of high-speed railways, the modernisation of ports and airports, and the development of transport corridors. These projects contribute to improving logistics and reducing transportation costs, which stimulates the domestic market and supports economic growth. It is worth noting that Chinese investments in transport infrastructure play an important role in the global improvement of transport networks and cost reduction, contributing to economic growth and development at both the national and international levels.

The assessment of construction technologies showed that Chinese companies supplied modern technologies and equipment for the construction and repair of infrastructure. This included the introduction of new methods and materials that increase the efficiency and durability of constructed facilities. Modern technologies have improved the quality of roads, bridges and railways, contributing to the creation of a reliable and sustainable transport network. However, the introduction of new technologies also required the training of local specialists and adaptation to local conditions. Wang and Yin (2022) concluded that modern construction technologies significantly affect the quality and durability of infrastructure. The use of new materials, such as high-strength concretes and corrosion-resistant alloys, can significantly increase the strength

and durability of structures (Bugayevskiy et al., 2017). Innovative methods such as prestressed structures and improved laying technologies help reduce the need for repairs and increase the reliability of facilities. However, in order to achieve maximum results, it is also important to consider the operating conditions and carry out regular maintenance.

The study by Willar et al. (2021) revealed that the introduction of modern construction methods can significantly increase the stability of the transport network. Intelligent transportation systems such as smart traffic lights and traffic monitoring systems optimise traffic flows and reduce congestion (Haikova et al., 2023). The use of environmentally friendly materials and technologies that are resistant to climate change helps to create a more reliable and sustainable infrastructure. These methods not only improve the functionality of the network, but also contribute to its durability and minimise the negative impact on the environment. These results confirm the above study, as they show a direct link between the introduction of modern construction technologies and improving the quality and durability of infrastructure. For example, the use of high-strength concretes and innovative protective coatings, as demonstrated in the study, directly affects the service life of construction sites, reducing their susceptibility to damage and the need for frequent repairs.

The analysis showed that the improvement of the transport infrastructure had a significant impact on the transport and logistics systems of Kyrgyzstan and the economic development of the country. Improved infrastructure has facilitated more efficient movement of goods and people, which has reduced transportation costs and increased the speed of delivery. This has created favourable conditions for business development, attracting investments and creating new jobs. In addition, the improved infrastructure has facilitated the country's integration into international trade networks, opening up new opportunities for the export and import of goods. Wang et al. (2021) also found that improving transport infrastructure directly contributes to economic development and optimisation of logistics systems. Modern roads, bridges, and ports improve connectivity between regions, reducing transportation costs and speeding up the delivery of goods (Babayev et al., 2017). This creates favourable conditions for business, attracts investments, and contributes to the creation of new jobs. Efficient logistics systems, in turn, allow companies to optimise supply chains and improve inventory management, which leads to increased productivity and competitiveness (Sinoimeri et al., 2024).

Hussain et al. (2021) concluded that the modernisation of transport routes significantly contributes to business growth and integration into international trade networks. Modern transport corridors, such as high-speed railways and upgraded ports, simplify access to global markets, reducing the time and cost of delivering goods. This allows companies to expand their markets, improve logistics, and increase competitiveness. As a result, businesses are able to effectively manage international supply chains and strengthen their positions in the global arena. These data are consistent with the theses given in the previous section, as they demonstrate how improving transport infrastructure and modernising transport routes directly contribute to economic growth and integration into international trade networks.

The study revealed that the impact of Chinese projects on sustainable development can be both positive and negative. Positive aspects included improving the quality of roads and the transport network, which contributed to economic growth and integration into international markets. Negative aspects included environmental and sustainability issues, as construction had an impact on the environment. In order to achieve sustainable development, it was necessary to develop and implement measures to minimise the negative impact on the environment and the local population. This included conducting environmental research and developing programmes to compensate and support local communities. Van Zanten and van Tulder (2021) also conducted a study, the findings of which confirmed that infrastructure projects have a dual impact on sustainable development, combining both positive and negative aspects. On the one hand, they contribute to economic growth by improving transport links,

creating jobs and providing access to basic services. On the other hand, such projects can have negative environmental consequences, including destruction of natural ecosystems, environmental pollution, and social problems such as displacement of local communities. Effective management and evaluation of these projects require careful consideration of all aspects to achieve balanced and sustainable development.

Yurui et al. (2021) also found that Chinese infrastructure initiatives, such as the "One Belt, One Road" project, have a significant impact on both the economy and the environment. Economically, they contribute to the development of trade routes, increased trade and investment in various regions, which leads to economic growth and improved infrastructure. However, the environmental consequences can be serious, including ecosystem destruction and environmental pollution. To achieve sustainable development, it is necessary to integrate environmental standards into design and implementation, including the use of environmentally friendly technologies and environmental impact assessments. Comparing the data obtained during the research, it can be concluded that infrastructure projects have both positive and negative effects on sustainable development. They contribute to economic growth and improved transport links, but can also lead to ecosystem destruction and social problems. In the case of Chinese infrastructure initiatives, the economic benefits, such as developing trade routes and attracting investment, are accompanied by significant environmental impacts. To achieve sustainable development, it is necessary to consider environmental principles and apply sustainable technologies.

The study showed that infrastructure projects contributed to the integration of Kyrgyzstan into regional transport and trade networks, increasing its strategic importance in Central Asia. The creation of efficient transport corridors has facilitated the movement of goods and people across borders, improving logistics and transportation of goods. This strengthened economic ties between the countries of the region, contributed to their economic development and increased stability. However, in order to fully realise these advantages, it was necessary to address the potential challenges associated with traffic flow management and the development of related infrastructure. Ma et al. (2021) concluded that infrastructure projects significantly contribute to integration into regional transport and trade networks, increasing the strategic importance of countries and regions. Improved transport links such as roads, bridges, and ports facilitate trade and resource sharing between regions, allowing for improved participation in global supply chains. This increases the investment attractiveness and contributes to economic growth, strengthening the strategic position in the international arena.

Gulamov et al. (2022) revealed that infrastructure projects in Central Asia play a key role in improving logistics and transportation of goods in the region. The development of new transport corridors and the modernisation of existing routes contribute to a more efficient movement of goods between Central Asia and other regions, reducing costs and delivery time (Kerimkhulle et al., 2023). This makes the region more competitive and supports the development of trade and economic cooperation, helping to attract investment and strengthen economic stability. When analysing the results of the study, it becomes clear that infrastructure projects play a key role in improving regional transport and trade links. They enhance the strategic importance of countries by facilitating participation in global supply chains and stimulating economic growth. In Central Asia, such projects improve logistics and transportation of goods, reducing costs and delivery time. This makes the region more competitive and promotes trade and investment.

In general, China's participation in infrastructure projects in Kyrgyzstan had both advantages and challenges for the sustainable development of transport and logistics systems. These projects have helped to modernise the transport and logistics infrastructure, improving the economic situation and strengthening trade ties. However, to achieve sustainable development, it was necessary to address potential environmental and social challenges, providing an integrated approach to planning and implementing infrastructure initiatives.

Such an approach would maximise the positive effects and minimise the negative impact on the environment and the local population.

5. Conclusions

The study showed that Chinese infrastructure projects in Kyrgyzstan play a significant role in the development of the country's transport network and economic growth. Chinese investments and financing have significantly contributed to the modernisation of key transport infrastructure such as roads, bridges, and railways. The Bishkek-Osh road modernisation project is a prime example demonstrating how Chinese tools and technologies can significantly improve transport routes by reducing the time and cost of transporting goods and passengers. This, in turn, stimulated the growth of trade and investment in Kyrgyzstan.

The supply of Chinese technologies and equipment for the construction and repair of infrastructure has allowed the introduction of modern methods and materials that increase the efficiency and durability of constructed facilities. This has improved the quality of roads, bridges, and railways, creating a reliable and sustainable transport network. Improved transport and logistics systems have contributed to more efficient movement of goods and people, reducing transportation costs and increasing the speed of delivery. This created favourable conditions for business development, attracting investments and creating new jobs, and also contributed to the country's integration into international trade networks.

Nevertheless, the study also revealed potential risks associated with the implementation of Chinese projects. In particular, environmental problems were noted, such as increased pollution levels and negative impacts on local ecosystems. Social aspects also required attention: improved infrastructure contributed to the creation of jobs, but caused the displacement of local communities and a change in their way of life. In order to achieve sustainable development, it was recommended to take into consideration both economic benefits and environmental and social consequences. It is necessary to develop and implement measures to minimise the negative impact on the environment and the local population, providing an integrated approach to the planning and implementation of infrastructure projects.

In general, China's participation in infrastructure projects in Kyrgyzstan has both advantages and challenges for the sustainable development of transport and logistics systems, requiring a balanced assessment and an integrated approach to maximise positive effects and minimise negative impacts. It is necessary to further investigate the long-term socio-economic and environmental consequences of Chinese infrastructure projects in Kyrgyzstan, and the development and implementation of strategies to minimise their negative impact. The limitation of the study was the lack of long-term data on the impact of Chinese infrastructure projects on local ecosystems and social structures in Kyrgyzstan.

Conflict of Interests and ethics

The authors declare no conflict of interests. The authors also declare full adherence to all journal research ethics policies, namely involving the participation of human subjects anonymity and/ or consent to publish.

References

Alaloul, W.S., Musarat, M.A., Rabbani, M.B.A., Iqbal, Q., Maqsoom, A., & Farooq, W. (2021). Construction sector contribution to economic stability: Malaysian GDP distribution. Sustainability, 13(9), 5012.

Babak, V.P., Babak, S.V., Eremenko, V.S., Kuts, Y.V., Myslovych, M.V., Scherbak, L.M., & Zaporozhets, A.O. (2021). Models and Measures for Atmospheric Pollution Monitoring. Studies in Systems, Decision and Control, 360, 227-266.

Babayev, V., Bekker, M., Shmukler, V., Bugayevskiy, S., Kaplin, R., & Krul, Y. (2017). Efficient construction of the motorway and highway bridge superstructure (experimental studies). MATEC Web of Conferences, 116, 02003.

Baialieva, G. (2023). The afterlife of industrialization: Flows and transformations in Kyrgyzstan. Tubingen, University of Tubingen.

Balbaa, M.E., Dadabaev, U., Akhmedova, D., & Iskandarova, M. (2024). Fostering economic growth and global trade through digitalized international transport corridors: Examining the role of the eTIR convention in the proposed China-Kyrgyzstan-Uzbekistan railways for Uzbekistan's development. American Journal of Business and Operations Research, 11(1), 31-42.

Bashir, M.F., Ma, B., Qin, Y., & Bashir, M.A. (2021). Evaluation of One Belt One Road publications: A bibliometric and literature review analysis. Environmental Science and Pollution Research, 28, 37016-37030.

Bruzzone, F., Cavallaro, F., & Nocera, S. (2021). The integration of passenger and freight transport for first-last mile operations. Transport Policy, 100, 31-48.

Bugayevskiy, S., Gerasymenko, V., Konyukhov, A., & Nikulin, V. (2017). Basics of modeling and technology of creating reinforced concrete elements of monofant system construction. MATEC Web of Conferences, 116, 02009.

Calabrese, L. (2024). Diversifying away from extractives: The Belt and Road initiative, Chinese capital and industrialisation in the Kyrgyz Republic. The European Journal of Development Research, 36, 601-638.

Cheng, Z., Wang, H., Xiong, W., Zhu, D., & Cheng, L. (2021). Public–private partnership as a driver of sustainable development: Toward a conceptual framework of sustainability-oriented PPP. Environment, Development and Sustainability, 23, 1043-1063.

Connolly, C., Keil, R., & Ali, S. H. (2021). Extended urbanisation and the spatialities of infectious disease: Demographic change, infrastructure and governance. Urban Studies, 58(2), 245-263.

Diao, M., Kong, H., & Zhao, J. (2021). Impacts of transportation network companies on urban mobility. Nature Sustainability, 4, 494-500.

Du, H., Li, Q., Liu, X., Peng, B., & Southworth, F. (2021). Costs and potentials of reducing CO2 emissions in China's transport sector: Findings from an energy system analysis. Energy, 234, 121163.

Galkin, A., Obolentseva, L., Balandina, I., Kush, E., Karpenko, V., & Bajdor, P. (2019). Last-mile delivery for consumer driven logistics. Transportation Research Procedia, 39, 74-83.

Gulamov, A., Masharipov, M., & Egamberdiyeva, K. (2022). Planning of new transit corridors-new opportunities for the development of transit in Uzbekistan. AIP Conference Proceedings, 2432, 030019.

Gulcimen, S., Aydogan, E.K., & Uzal, N. (2021). Life cycle sustainability assessment of a light rail transit system: Integration of environmental, economic, and social impacts. Integrated Environmental Assessment and Management, 17(5), 1070-1082.

Haikova, T., Moroz, M., Zahorianskyi, V., & Buriennikov, Yu. (2023). Project analysis of digital technologies in supply chain management. Journal of Mechanical Engineering and Transport, 9(1), 17-22.

Hussain, S., Rafiq, M., Quddus, A., Ahmad, N., Pham, P.T. 2021. China-Pakistan economic corridor: Cooperate investment development and economic modernization encouragement. Journal of Contemporary Issues in Business and Government, 27(1), 96-108. https://publikace.k.utb.cz/handle/10563/1010258

Jakubik, P., Kerimkhulle, S., & Teleuova, S. (2017). How to anticipate recession via transport indices. Ekonomicky casopis, 65(10), 972-990.

Kadłubek, M., Thalassinos, E., Domagała, J., Grabowska, S., Saniuk, S. 2022. Intelligent transportation system applications and logistics resources for logistics customer service in road freight transport enterprises. Energies, 15(13), 4668. https://doi.org/10.3390/en15134668

Kerimkhulle, S., Aitkozha, Z., Saliyeva, A., Kerimkulov, Z., Adalbek, A., & Taberkhan, R. (2023). Using Technical and Structural Coefficients of Economic Statistics to Equalize Flows of Input-Output Table. Lecture Notes in Networks and Systems, 596, 501-511.

Komendantova, N., Rovenskaya, E., Strelkovskii, N., & Rodriguez, F.S. (2022). Impacts of various connectivity processes in central Asia on sustainable development of Kyrgyzstan. Sustainability, 14(12), 6998.

Lami, A., Fernandes, G., & Souad, S.B. (2021). A conceptual hybrid project management model for construction projects. Procedia Computer Science, 181, 921-930.

Lu, Y., Springer, C., & Steffen, B. (2024). Cofinancing and infrastructure project outcomes in Chinese lending and overseas development finance. World Development, 175, 106473.

Ma, Q., Jia, P., She, X., Haralambides, H., & Kuang, H. (2021). Port integration and regional economic development: Lessons from China. Transport Policy, 110, 430-439.

Magazzino, C., & Mele, M. (2021). On the relationship between transportation infrastructure and economic development in China. Research in Transportation Economics, 88, 100947.

Malik, A., Parks, B., Russell, B., Lin, J.J., Walsh, K., Solomon, K., Zhang, S., Elston, T.B., & Goodman, S. (2021). Banking on the Belt and Road: Insights from a new global dataset of 13,427 Chinese development projects. Williamsburg: AidData at William & Mary.

Moldaliyeva, A., Kilybayeva, P., Birimkulova, G., Ilyassova, Z., & Atayeva, T. (2023). Participation of Central Asian countries in Central Asian regional economic cooperation: Transport, energy. Global Perspectives, 4(1), 88417.

Okudan, O., Budayan, C., & Dikmen, I. (2021). A knowledge-based risk management tool for construction projects using case-based reasoning. Expert Systems with Applications, 173, 114776.

Pal, P., Gopal, P.R.C., & Ramkumar, M. (2023). Impact of transportation on climate change: An ecological modernization theoretical perspective. Transport Policy, 130, 167-183.

Puplampu, D.A., & Boafo, Y.A. (2021). Exploring the impacts of urban expansion on green spaces availability and delivery of ecosystem services in the Accra metropolis. Environmental Challenges, 5, 100283.

Sinoimeri, D., Teta, J., Prifti, V., & Lazaj, A. (2024). Information Technology in Supply Chain Management. Case Study. Lecture Notes on Multidisciplinary Industrial Engineering, 2090, 35-44.

Tassybekov, Z., Bekenov, T., & Nussupbek, Z. (2020). Assessment of Compaction of the Road Base from Repeated Exposure to Frequently Repeated Loads of Self-propelled Road Roller. Lecture Notes in Intelligent Transportation and Infrastructure, 1382, 164-170.

Trusova, N.V., Yeremenko, D.V., Karman, S.V., Kolokolchykova, I.V., & Skrypnyk, S.V. (2021). Digitalization of investment-innovative activities of the trade business entities in network IT-System. Estudios de Economia Aplicada, 39(5). https://doi.org/10.25115/eea.v39i5.4912

Van Zanten, J.A., & van Tulder, R. (2021). Towards nexus-based governance: Defining interactions between economic activities and Sustainable Development Goals (SDGs). International Journal of Sustainable Development & World Ecology, 28(3), 210-226.

Wang, C., Kim, Y.S., & Kim, C.Y. (2021). Causality between logistics infrastructure and economic development in China. Transport Policy, 100, 49-58.

Wang, M., & Yin, X. (2022). Construction and maintenance of urban underground infrastructure with digital technologies. Automation in Construction, 141, 104464.

Willar, D., Waney, E.V.Y., Pangemanan, D.D.G., & Mait, R.E.G. (2021). Sustainable construction practices in the execution of infrastructure projects: The extent of implementation. Smart and Sustainable Built Environment, 10(1), 106-124.

Wolszczak-Derlacz, J., & Lu, Y. (2022). The role of the One-Belt One-Road initiative in China's exports and global value chains. EQUILIBRIUM Quarterly Journal of Economics and Economic Policy, 17(2), 317-341.

Xing, W., Hao, J.L., Qian, L., Tam, V.W., & Sikora, K.S. (2021). Implementing lean construction techniques and management methods in Chinese projects: A case study in Suzhou, China. Journal of Cleaner Production, 286, 124944.

Yurui, L., Xuanchang, Z., Zhi, C., Zhengjia, L., Zhi, L., & Yansui, L. (2021). Towards the progress of ecological restoration and economic development in China's Loess Plateau and strategy for more sustainable development. Science of the Total Environment, 756, 143676.

Yusupova, G.N., Yugai, N.A., Choguldurov, M.D., & Khubieva, S.A. (2024). Development of water resources infrastructure in the Kyrgyz Republic: Conflict potential. BIO Web of Conferences, 83, 04001.