Role of economic growth and Railways to achieve environmental sustainability in Kazakhstan and Tadzhikistan

Abstract: Global climate change, caused by greenhouse gas (ghg) emissions, particularly carbon dioxide (CO2), poses an unparalleled threat to the environment, development and sustainability. This study examines economic growth and rail transport in Kazakhstan and Takikstan to achieve environmental sustainability by reducing CO2 emissions. Dynamic ordinary least squares (DOLS) method was used to analyze the time series data from 2005 to 2019. DOLS estimates show that for Kazakhstan, the correlation coefficient between economic growth and carbon dioxide emissions is positive and significant, indicating that 1% economic growth is associated with 0.197% increase in carbon dioxide emissions; for Takikstan, the correlation coefficient between economic growth and carbon dioxide is negative and significant. Showing that an economic growth of 1% is associated with a reduction in CO2 of -1.03%, the correlation coefficient between rail transport and CO2 emissions is negative and significant for both countries. The empirical results show that for Kazakhstan, economic growth increases CO2 emissions and rail transport reduces CO2 emissions. For Takikstan, economic growth has reduced CO2 emissions, and rail transport has reduced CO2 emissions. This paper provides policy recommendations for low carbon economy and environmental sustainability in Kazakhstan and Takikstan.

Keywords: *DOLS, FMOLS, Climate change, CO2 emissions, Economic growth, Railway transports*

1 Introduction

Global climate change is an urgent problem to be solved in the 21st century. CO2 is mainly released by human activities such as fossil fuel burning and deforestation. The continued increase in CO2 emissions is projected to have a huge impact on the global climate system, with catastrophic consequences for all sectors of society (IPCC, 2021). To maintain environmental sustainability, global temperature reduction should be prioritized regardless of the level of development (IPCC, 2021). Improving environmental sustainability by reducing CO2 emissions has become a global concern. Therefore, the world needs to take action and work together to reduce carbon dioxide emissions in order to protect the earth's ecosystem and the sustainable development of human society.

Kazakhstan is the world's largest landlocked country with abundant natural resources and one of the world's largest oil and gas exporters (Wang et al. 2019). Kazakhstan faces serious environmental problems due to CO2 emissions from fossil fuel energy consumption (Wang et al. 2019). According to the Paris Agreement, Kazakhstan committed to achieve the unconditional goal of reducing greenhouse gas emissions by 15% and the conditional goal of 25% by 2030 compared with 1990. Tajikistan is a mountainous country with abundant water resources and renewable energy

potential. However, Tajikistan relies heavily on fossil fuels in the energy sector, which leads to high CO2 emissions. In response to the global climate change challenge, Tajikistan has ratified the Paris Agreement and set emission reduction targets.

Both Kazakhstan and Tajikistan face the challenge of reducing emissions to achieve environmental sustainability. Among them, economic growth and transportation have potential impacts on CO2 emissions. With a comprehensive understanding of Kazakhstan's and Tajikistan's emission reduction potential, policymakers need to balance the relationship between the two when formulating policies aimed at mitigating climate change and achieving sustainable development.

Since independence in 1991, Kazakhstan has been one of the fastest growing transition economies in the world (Akbota and Baek, 2018). Kazakhstan's Gross Domestic Product (GDP) increased approximately sevenfold from $25 billion in 1991 to $182 billion in 2019 (World Bank, 2021). However, due to the limitation of natural conditions, the total GDP of Tajikistan increased between 1991 and 2020 (Kakharov, A. (1959)), but the growth rate was relatively slow. The country's economy is relatively small, constrained by limited resources, inadequate infrastructure, and other internal and external factors. A key question is therefore whether increasing economic development in Kazakhstan and Tajikistan is compatible with environmental sustainability (emission reduction).

Since Kazakhstan and Tajikistan are landlocked countries, the construction of railways can reduce carbon dioxide emissions to a certain extent. Railways have the advantages of high efficiency and high volume in the transportation of goods. Trains can carry more cargo than minivans or trucks, reducing the number of vehicles and congestion in transit. Large-scale centralized cargo transportation can improve logistics efficiency and reduce energy consumption and carbon dioxide emissions in transportation. CO2 emissions can be further reduced by adopting an electrified railway system. Compared with traditional fuel power systems, electrified railways use electricity for energy, reducing fuel consumption and related emissions. The carbon footprint of rail transport can be further reduced by introducing renewable or low-carbon energy sources for electricity supply.

To date, relatively few studies have used econometric methods to explore the mitigation potential of Kazakhstan and Tajikistan. Therefore, this study aims to study the dynamic impact of economic growth and rail transport on CO2 emissions in Kazakhstan and Tajikistan using the DOLS approach. This study is important as it will support policy development in Kazakhstan and Tajikistan. The findings of the study will provide policymakers with more comprehensive and useful information to formulate successful policies in areas such as a low-carbon economy, promoting the use of renewable energy and financing technological progress. Environmental sustainability can be ensured by reducing emissions in Kazakhstan and Tajikistan. In addition, the findings of this survey will also contribute to environmental policy assessment and further policy development. The findings of the study could also provide recommendations for other developing countries to develop successful strategies to achieve environmental sustainability and strengthen climate change mitigation and adaptation strategies. Taken together, this study fills a knowledge gap in the research field of emission reduction potential in Kazakhstan and Tajikistan, and provides important reference and guidance for policy makers.

2 Methodology

2.1 Data

This study uses the dynamic least squares (DOLS) cointegration method of Pesaran and Shin (1995) and Pesaran et al. (2001) to empirically examine the dynamic impact of economic growth and rail transport on CO2 emissions in Kazakhstan and Tajikistan analyze. The time series data for Kazakhstan and Tajikistan from 2005 to 2019 come from the World Development Indicators (WDI) dataset. This study takes CO2 emissions as the dependent variable, and economic growth and railway transportation as the explanatory variables. This study measures carbon dioxide emissions in metric tons per capita, economic growth in GDP per capita (constant local currency unit) and railway transport construction in terms of rail freight traffic. Finally, the variables were log-transformed to ensure that the data were normally distributed. Table 1 presents the variables and their logarithmic forms, units of measurement, and data sources.

Variables	Description	Logarithmic forms	Units	Sources
CO2	CO2 emissions	LCO2	Metric tons per capita	WDI
GDP	Economic growth	LGDP	GDP per capita (current US$)	WDI
RGT	Railways, goods transported (million ton-km)	LRGT	(million ton-km)	WDI

Table 1 Variables with their logarithmic forms, units, and data sources.

2.2 Empirical model

This study uses CO2 as an indicator of environmental degradation caused by greenhouse gas emissions. Therefore, this study takes CO2 reduction as an indicator of environmental sustainability. Theoretically, if CO2 emissions are related to income and rail transport, then within the framework of the standard Marshallese demand function for time t (Friedman, 1949), the following function can be written:

$$\mathrm{CO_{2t}} = f(\mathrm{GDP_t}; \mathrm{RGT_t}) \qquad (1)$$

The equation depicts the empirical model:

$$\mathrm{CO2t} = \tau_0 + \tau_1 \mathrm{GDP_t} + \tau_2 \mathrm{RGT_t} + \varepsilon_t \qquad (2)$$

Where τ_0 and ε_t are represent the intercept term and the error term, respectively. τ_1 and τ_2 are the coefficient.

The logarithmic representation is shown in formula 3

$$\mathrm{LCO2t} = \tau_0 + \tau_1 \mathrm{LGDP_t} + \tau_2 \mathrm{LRGT_t} + \varepsilon_t \qquad (3)$$

Where LCO2 is the logarithmic form of CO2, the LGDP is the logarithmic form of GDP, the LRGT is the logarithmic form of RGT.

According to Begum et al. (2020), when considering variables with constant terms, issues such as small sample bias, endogeneity, and autocorrelation can be addressed. After confirming that there is a co-integration relationship among the variables, the DOLS estimation of the long-term coefficients can be performed using formula (4). The use of this method helps to eliminate the problem of bias in data analysis and provides more accurate estimation results.

$$\Delta \mathrm{LCO2_t} = \&\tau_0 + \tau_1 \mathrm{LCO2_{t-1}} + \tau_2 \mathrm{LGDP_{t-1}} + \tau_3 \mathrm{LRGT_{t-1}} + + \sum_{i=1}^{q} \gamma_1 \Delta \mathrm{LCO2_{t-i}} + \sum_{i=1}^{q} \gamma_2 \Delta \mathrm{LGDP2_{t-i}} + \sum_{i=1}^{q} \gamma_3 \Delta \mathrm{LRGT_{t-i}} + \varepsilon_t \qquad (4)$$

Where Δ is the first difference and the q is the optimum lag length

2.3 Flow chart of the analysis

The flowchart used in the study to explore the dynamic interaction of economic growth and rail transport on CO2 emissions in Kazakhstan and Tajikistan is shown in Figure 1.

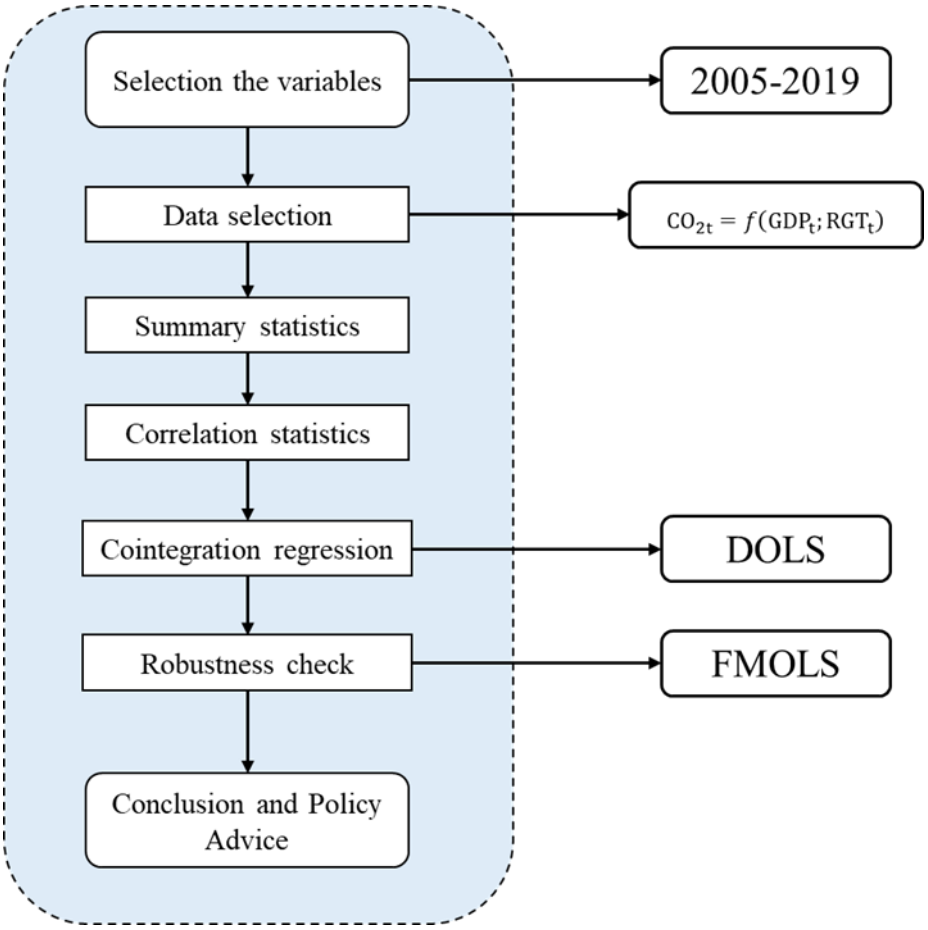


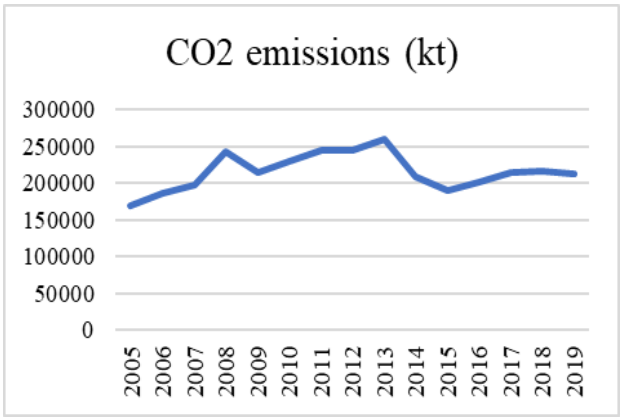
Figure 1. The analysis flow chart is used in this study.

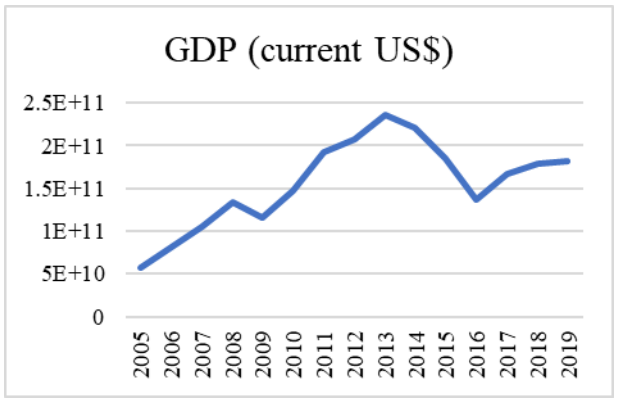
2.4 DOLS cointegration regression

The study employed the extended ordinary least squares estimator (DOLS) to analyze time series data. The DOLS cointegration test considered the explanatory variables and their leading and lagged initial difference terms to adjust for endogeneity, and the standard deviation was calculated using an error covariance matrix resistant to serial correlation. Since the error terms are orthogonal and the standard deviation of the DOLS estimator has a normal asymptotic distribution, the statistical significance of the variables can be tested reliably. The DOLS approach models the dependent variable by estimating level, leading and lagging explanatory variables, effectively allowing individual variables to be integrated in a cointegration framework. The main advantage of DOLS estimation is that it can handle mixed-order integrals of individual variables present in cointegration profiles. This means that the DOLS method can more accurately capture the long-term relationship between variables and provide a more reliable estimate of the cointegration relationship. Therefore, the DOLS method adopted in this study has important advantages in processing time series data and cointegration analysis.

3 Findings

3.1 Trend of Railways, emission, and economic growth





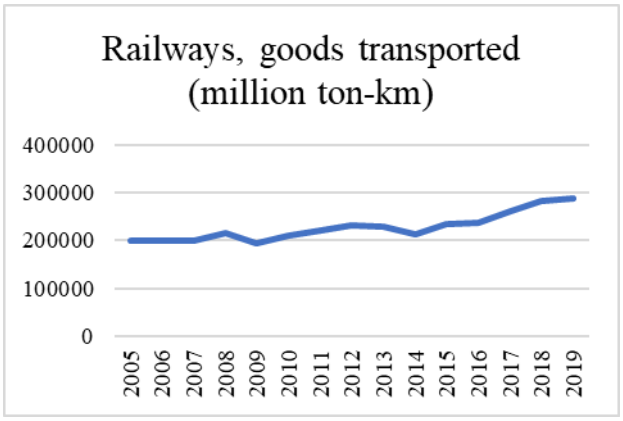
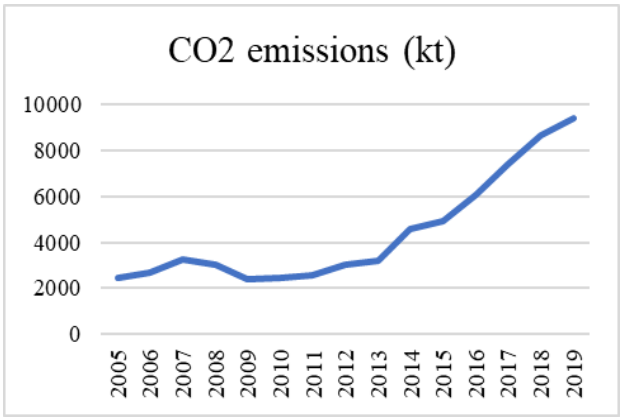


Figure 2. Annual trend of CO2 emissions, GDP and railways, goods transported of Kazakhstan



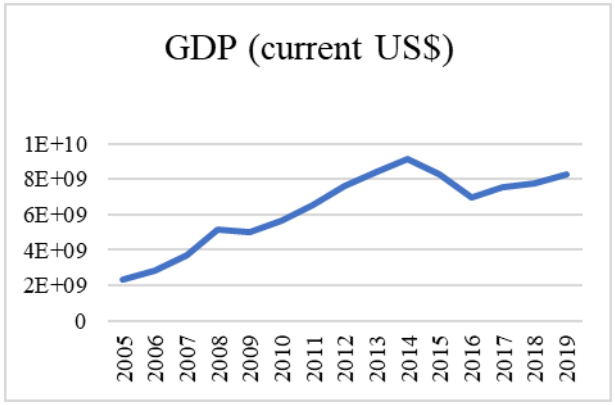


Figure 3. Annual trend of CO2 emissions, GDP and railways, goods transported of Takikstan

Annual trends in CO2 emissions, economic growth, and rail transport in Kazakhstan are shown in Figure 2. Annual trends show an upward trend in Kazakhstan's CO2, economy and rail transport since 2005.

Annual trends in CO2 emissions, economic growth, and rail transport in Tajikistan are shown in 32. The annual trend shows that since 2005, Kazakhstan's CO2 economy has shown an upward trend. The rail transport is showing a downward trend.

3.2 Summary statistics

The outcomes of the summary measures amid variables are shown in Table 2 and Table 3

	Sample numbers	Max	Min	Average Value	Std. Dev.	Median	variance	kurtosis	skew
LCO2	15	2.731	2.386	2.548	0.12	2.494	0.014	-1.436	0.36
LRGT	15	12.575	12.18	12.331	0.124	12.3	0.015	-0.177	0.825
LGDP	15	26.19	24.768	25.713	0.394	25.84	0.155	0.981	-1.124

Table 2 Summary statistics of the variables of Kazakhstan

	Sample numbers	Max	Min	Average Value	Std. Dev.	Median	variance	kurtosis	skew
LCO2	15	0.009	-1.136	-0.713	0.398	-0.879	0.159	-0.877	0.733
LRGT	15	7.156	5.106	6.301	0.748	6.319	0.559	-1.546	-0.182
LGDP	15	22.933	21.562	22.501	0.42	22.668	0.176	0.519	-1.201

Table 3 Summary statistics of the variables of Takikstan

3.3 Results obtained from DOLS

For Kazakhstan, the DOLS results estimated using Eq.(4) are shown in Table 5. Other variables being constant, the long-run predictive coefficient of LGDP is positive and significant at 1%, meaning that 1% economic growth would lead to a 0.197% increase in CO2 emissions. The finding suggests that, in the long run, economic growth can lead to environmental degradation in Kazakhstan. At the same time, other variables being constant, the long-term prediction coefficient of LRGT is negative and significant at the 1% level, meaning that a 1% increase in the volume of goods transported by rail would reduce CO2 emissions in Kazakhstan by -0.89%. We also used a variety of diagnostic tests to assess the goodness of fit of our estimated model. First, the R2 value is 0.9686, which indicates that the estimated regression model fits well. This means that the independent variable may account for F-96% of the variation in the dependent variable. Second, F-statistics show that the dependent and independent variables support estimated DOLS regression.

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

	(1)
VARIABLES	CO2
Railways	-0.890***
	(0.285)
GDP	0.197***
	(0.0680)
Constant	8.452**
	(3.323)
Observations	14
R-squared	0.968

Table 4 Variables with their logarithmic forms, units, and data sources.

For Takikstan, the DOLS results estimated using Eq.(4) are shown in Table 6. With other variables held constant, the long-run forecast coefficient of LGDP is negative and significant at the 1% level, meaning that a 1% economic growth would lead to a -1.03% reduction in CO2 emissions. This finding suggests that, in the long run, economic growth will reduce CO2 emissions for Takikstan. At the same time, other variables being constant, the long-term prediction coefficient of LRGT is negative and significant at the 1% level, meaning that a 1% increase in the volume of goods transported by rail would reduce CO2 emissions in Kazakhstan by -0.96%. We also used a variety of diagnostic tests to assess the goodness of fit of our estimated model. First, the R2 value is 0.991, which indicates that the estimated regression model fits well. This means that the independent variable may account for F-99% of the change in the dependent variable. Second, F-statistics show that the dependent and independent variables support estimated DOLS regression.

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

	(1)

VARIABLES	CO2
Railways	-0.961***
	(0.219)
GDP	-1.030***
	(0.307)
Constant	28.63***
	(8.001)
Observations	14
R-squared	0.991

Table 5 Variables with their logarithmic forms, units, and data sources.

3.4 Robustness check

We used FMOLS to verify the consistency of DOLS estimates. The FMOLS estimation results of the model are shown in Table 7 and Table 8. The results of FMOLS prove the robustness of DOLS estimates. Both FMOLS results verified the positive correlation between GDP and CO2 emissions in Kazakhstan and the negative correlation between GDP and CO2 emissions in Takikstan at a significant level of 1%. FMOLS results further demonstrated a significant negative correlation between rail transport and CO2 emissions. In addition, the R2 value of FMOLS reflects the goodness of fit of the model. Thus, it can be said that for Kazakhstan, the increase in GDP promotes CO2 emissions, while for Takikstan, the increase in GDP reduces CO2 emissions, and for both countries, the increase in rail transport reduces CO2 emissions.

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

	(1)
VARIABLES	CO2
Railways	-0.668***
	(0.134)
GDP	0.291***
	(0.0541)
Constant	3.266**
	(1.529)
Observations	14
R-squared	0.809

Table 6 Variables with their logarithmic forms, units, and data sources.

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

	(1)
VARIABLES	CO2
Railways	-0.486***
	(0.0291)

GDP	-0.185***
	(0.0629)
Constant	6.703***
	(1.564)
Observations	14
R-squared	0.800

Table 7 Variables with their logarithmic forms, units, and data sources.

4 Discussion

This study first investigates the relationship between economic growth and environmental pollution in Kazakhstan and Takikstan. According to the results of the study, due to the rapid development of Kazakhstan's economy, the growth of Kazakhstan's GDP has a significant positive effect on carbon dioxide emissions in the long run. Zhang(2021) found a significant positive correlation between GDP and CO2 emissions in Kazakhstan. The main reason is that Kazakhstan is undergoing large-scale energy development and infrastructure construction, and Kazakhstan adopted the concept of transition to a green economy in 2013. The transition to green growth is a necessary priority for Kazakhstan, as the country's economic development is currently focused on extractive industries and raw material export materials. At the same time, energy intensity and pollution levels are relatively high and energy efficiency is low in most economic sectors. The main articles of the concept of transition to a green economy of Kazakhstan set out the principles of systematic transformation aimed at achieving the transition of the national economy to a new level of development, while minimizing the man-made load on the environment. The Kazakh government has taken some measures aimed at reducing energy consumption, but the relationship between economic growth and CO2 emissions is still positive and needs to be optimized in the future. Given this situation, the main challenge of Kazakhstan's transition to a green economy begins with the transformation of the energy base and the reduction of greenhouse gas emissions by improving energy efficiency in all economic sectors. In order to reduce the demand and use of energy in various industrial sectors, Kazakhstan aims to move towards sustainable resource consumption through the implementation of low-carbon strategies. According to the results of the study, since Takikistan is mainly based on agricultural and mineral exports, the GDP growth of Takikistan has a significant negative effect on carbon dioxide emissions. The main reason is that there is no large-scale energy use and infrastructure construction in Takikstan at this stage. In the long term, with the increasing global concern for environmental issues and the increasing international regulation of carbon emissions, Takikstan still needs to actively promote the adoption of sustainable development Goals and green technologies.

Secondly, according to the results of the study, for Kazakhstan and Takikstan, an increase in rail transport could lead to a decrease in CO2 emissions. This may be due to the interaction of several factors. First, rail transport may have lower carbon emissions than other modes of transport, such as road transport or air transport. Compared to individual means of transport such as cars and planes, rail transport is often able to carry more goods and passengers, thereby reducing carbon emissions per unit of transport. Rail trains are more energy efficient and run on electricity or on-track fuel, which can reduce carbon emissions and dependence on fossil fuels. Secondly, the development of rail transport may have facilitated inter-regional trade and economic integration. By improving logistics and connecting transport networks between different regions, rail can provide a more

efficient and reliable way to move goods and people. This may have encouraged cross-border trade and business activity, reducing the need for long-distance road and air transport. Since rail transport typically has a lower level of carbon emissions, this shift could lead to an overall reduction in CO2 emissions. In addition, the development of rail transport may also bring a boost to environmental policy. As concerns about climate change and sustainable development increase, governments and international organizations are likely to encourage rail transport as an environmentally friendly mode of transport. The government may take measures to encourage the development of rail transport, such as providing financial support, building new railway lines and improving existing infrastructure. These initiatives may play a positive role in reducing carbon emissions and provide favorable conditions for the growth of rail transport.

In conclusion, for Kazakhstan and Takikstan, the development of rail transport can provide a more sustainable mode of transport, reduce dependence on high-carbon emission modes of transport, and provide a win-win opportunity for economic growth and environmental protection

5 Conclusion and policy implications

5.1 Conclusion

This study explores the potential of economic growth and rail transport in Kazakhstan and Takikstan to achieve environmental sustainability by reducing carbon emissions. Time series data for the period 2005 to 2019 were used to examine the dynamic effects of the variables. DOLS was used to capture the long-term impact of economic growth and rail transport on CO2 emissions in Kazakhstan and Takikstan. The empirical results show that for Kazakhstan, economic growth increases Kazakhstan's CO2 emissions, and increased rail transport can reduce CO2 emissions. For Takikstan, economic growth has reduced national CO2 emissions, while increased rail transport has also reduced CO2 emissions. FMOLS was used to verify the robustness of the results. The results of this survey contribute to environmental policy assessment and further policy formulation to reduce the impact of climate change by strengthening policies and action plans, thereby ensuring environmental sustainability and preparing Kazakhstan and Takikstan for a 1.5°C world.

5.2 Policy implications

Based on my conclusions on the relationship between economic growth and CO2 emissions, and between rail transport and CO2 emissions in Kazakhstan and Takikstan, I offer the following policy recommendations aimed at promoting economic development while reducing CO2 emissions.

Promote sustainable economic growth: Develop and implement a package of sustainable development policies that encourage the adoption of environmentally friendly technologies and clean energy and reduce reliance on carbon-intensive industries. By promoting the development of green industries and environmentally friendly investments, a win-win situation of economic growth and lower carbon emissions can be achieved.

Strengthen energy efficiency: Develop and enforce energy efficiency standards and measures to encourage enterprises and residents to adopt energy-efficient technologies and equipment. By improving energy efficiency, energy consumption and carbon emissions can be reduced. In addition, promoting energy efficiency in buildings and transportation is also an important part of the process.

Development of renewable energy: actively promote the development of renewable energy sources, such as solar and wind power. Provide preferential policies and financial support for renewable energy projects, attract private investment and build clean energy infrastructure. Gradually reduce reliance on traditional coal-fired power generation to reduce carbon emission levels.

Encourage sustainable modes of transport: Continue to invest in and improve rail transport infrastructure to increase rail capacity and efficiency. At the same time, policies should be developed to encourage citizens to choose low-carbon modes of transport such as public transport, cycling and walking. Optimize urban planning to reduce urban traffic congestion and promote sustainable mobility within cities.

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