Contribution of Finance and Transport Indicators on Carbon Emissions: Evidence from Eurasian Countries

Kenan İLARSLAN¹, Tuğrul BAYAT²

ABSTRACT
Carbon emission is one of the most significant causes of environmental degradation, global warming, and extraordinary meteorological events. It has reached a level that threatens the future of countries and human beings. To combat carbon emission, it is necessary to know the causes for developing policies. Environmental quality is a fundamental aspect of sustainable development in economies worldwide. In this context, Eurasian geography has always been an important region in the history of the world with its location, underground, and surface resources. Today, the region makes its strategic importance even more evident. The communist USSR ruled Eurasian countries, which served as a buffer between the Western world and China for many years. These countries, which gained their independence in the 1990s, have not yet fully captured the values of the modern world, such as democracy and a free market economy. This study focuses on Eurasian countries. This study aimed to determine the factors affecting carbon emissions. Foreign direct investment and transportation contribute significantly to carbon emission, which reduces environmental quality. Therefore, in this study, we investigated whether rail and road passenger transport and foreign direct investment affect carbon emission in Eurasian countries. The concurrent panel quantile regression method was used to estimate this relationship between 1992 and 2020. The results revealed that rail and road passenger transport and foreign direct investment increase emissions. Additionally, no clear result could be obtained regarding the effect of the GDP per capita variable. To support these findings, analyses were performed using the robust quantile regression method, and strong empirical evidence was obtained, particularly for the impacts of foreign direct investment and rail passenger transport on emissions.

Keywords: Environmental quality, Transportation, Foreign direct investment, Quantile regression

JEL Classification: Q50, L91, F21, C21

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1. Introduction

The intensive use of fossil resources has brought about significant problems for human beings, the environment, and the world since the Industrial Revolution. Greenhouse gas (GHG) emissions from carbon are the main cause of climate change and many other meteorological events. As Leal and Marques (2022) emphasise, climate change is largely influenced by anthropogenic behaviours, such as the manufacturing of goods and services, energy consumption (ENCO), transportation, and agricultural activities. Extreme environmental and meteorological events caused by climate change have reached dimensions that threaten the future of humanity and our planet. According to the Global Risks Report 2022 by the World Economic Forum (2022), three potentially most serious global risks relate to environmental factors for the next decade: extreme weather, climate action failure, and loss of biodiversity.

This study provides empirical evidence of the effect of foreign direct investment (FDI) inflows and rail (RAILpt) and road (ROADpt) passenger transport on carbon emission (COEm) in Eurasia. The results are anticipated to have considerable policy implications for decision makers in the struggle against climate change. In this sense, the link between FDIs and the environment was examined within the structure of two reverse hypotheses. The initial hypothesis is the Pollution Haven Hypothesis (PHav), which posits that multinational companies in industrial economies tend to relocate heavy pollution industries in their economies to emerging economies. Environmental rules and regulations are less feasible to comply with in these developed economies because of carbon taxes and higher operational costs. Owing to growing economic activity, FDIs boost economic activity and ENCO. Therefore, pollution-intensive industries utilising outdated and unfriendly technologies that have been relocated through FDIs significantly boost GHG emissions and, thus, environmental destruction in these economies (Cil, 2022; Wang and Luo, 2022; Musah et al, 2022; Apergis, Pinar and Unlu, 2022; Chaudhry et al, 2022; Bashir, 2022; Akram et al, 2022a; Firoj et al, 2023; Bulut et al, 2022). However, in addition to poor environmental protections in developing countries, an abundance of natural resources, inexpensive labour,
and low tax rates (Handoyo et al., 2022; Pavel, Tepperova and Arltova, 2021) are also attractive factors for FDI. The other hypothesis is the Pollution Halo Hypothesis (PHal), which argues that foreign companies, particularly those from industrialised economies, bring advanced, cleaner technologies and new management techniques that can improve the environmental quality of the host country (Liu et al., 2022; Gao et al., 2022; Caetano et al., 2022; Polloni-Silva et al., 2021; Xu et al., 2021a; Duan and Jiang, 2021; Bandyopadhyay and Rej, 2021). Therefore, FDIs also reduce environmental pollution and improve environmental quality in host countries. Tayyar (2022) draw attention to the fact that the management expertise, efficiency of energy, and environmental practices of organizations established in the host economy by FDIs can be followed as examples and implemented by domestic corporations. Practices arising from such foreign capital inflows may thus have spillover effects and improve environmental quality.

Since the Industrial Revolution and with globalization, transportation has played an increasingly prominent social and economic role by connecting people to each other and to goods and services. Global transport services have seen significant increases in both passenger and freight transport, particularly given overall economic growth and increased international trade (Godil et al., 2020). Various activities that impact the economy, such as large-scale improvements in transport infrastructure, heavy vehicular traffic, population increases, and economic development, have boosted the demand for means of transport, posing a serious threat to the long-term environmental outlook. For example, the construction of highways, railways, airports, and ports requires vast resources, such as land, energy, and technology, also involving industrialization, urbanization, and economic externalities that directly or indirectly decrease green spaces and increase GHG emissions. Eventually, the quality of the environment deteriorates over time (Khan et al. 2021b). The transportation industry is a significant source of COEm, accounting for approximately 25% of the total emissions (IPPC, 2018; Eurostat, 2020; Seum, Ehrenberger and Pregger, 2020; Sohail et al., 2021; Churchill et al., 2021). According to 2018 data, global COEm from transportation ran up to 8 billion tonnes, corresponding to approximately 24% of total energy-related emissions (IEA,
Due to the lack of effective reduction strategies, COEm from the global transportation industry is projected to increase by 60% by 2050 (ITF, 2019). An analysis of energy usage revealed that highway and rail transportation emit a significant amount of COEm (Heinold, 2020), and transportation-related COEm are projected to continue rising owing to ENCO. Passenger and freight transport, as its two subsectors, have many similarities and important differences. Both passenger and freight turnover and COEm tend to follow economic growth patterns (Hussain, Khan and Xia, 2022). In addition, road transport-related ENCO introduces high-density emissions and exceeds rail and water transport-related emissions (Lin, Luo and Yang, 2019). Likewise, consumption demands related to private automobile use also increase with road infrastructure development and rising income levels. Rising numbers of vehicles increase ENCO and create traffic problems in cities. Traffic problems and exhaust emissions are interrelated, as heavy traffic increases ENCO by increasing travel times (Shi et al., 2018; Lu et al., 2021). Meanwhile, rail transport is the principal means of conveyance between places such as cities, provinces, and countries. It has the distinction of larger freight capacity, lower ENCO, and greater safety and comfort, making it more efficient and inexpensive than long-haul road transport. In recent years, high-speed rail systems have developed rapidly. Aside from lower ENCO and operating costs, it offers incomparable advantages in terms of transport efficiency, safety, timeliness, and convenience, drastically changing the travel landscape while also replacing road traffic to a certain extent (Li and Luo, 2020). Rail transport has significantly streamlined economic activities and social interactions while adding timeliness and reliability to transport systems (Rodrique, Comtois and Slack, 2020).

In line with the theoretical background, this study empirically scrutinises the impacts of FDI inflows and rail and road passenger transport on COEm through a sample of eight Eurasian countries. It was designed within the framework of the following research questions:

Research Question 1: Do FDIs affect COEm?
Research Question 2: Does rail passenger transport affect COEm?
Research Question 3: Does road passenger transport impact COEm?
Research Question 4: Does GDP per capita impact COEm?
This study is important in the context of Eurasian countries for several reasons. First, Eurasian geography has occupied a strategic position throughout history, as it is at the intersection of Eastern and Western civilisations and religions. The region’s strategic and geo-political importance is expressed in Mackinder’s Heartland Theory (1904), which argued that whoever controlled Eastern Europe—the “Heartland”—controlled the world, as well as in Brzezinski’s (1998) work describing Eurasia as the centre of world power. Second, the region attracts the attention of countries and businesses in terms of investment and cooperation opportunities because of its underground and surface treasures. For instance, the World Bank (2014) data states that Eurasia is home to the greatest fossil energy and mineral ore reserves. Third, as stated by Chen et al. (2019), the region’s ecosystem is susceptible to risks related to global climate change and anthropogenic activities. In addition, Xenarios, Gafurov and Schmidt-Vogt (2019) identified Kyrgyzstan and Tajikistan as the most climate-sensitive countries in the former Soviet Union. Batmunkh et al. (2022) drew attention to the recent increase in temperature and humidity in Central Asia. Poberezhskaya and Bychkova (2022) emphasized that climate change adversely affects Kazakhstan’s already vulnerable water security. In short, climate change, which is largely caused by COEm, carries significant environmental, economic, and sociological risks. In this direction, All Eurasian countries have become members of the Paris Climate Agreement, which was signed in 2015 and came into force in 2016, aiming to combat climate change and global warming at the global level and imposing certain obligations on the party countries. Kyrgyzstan became the last country in the region to ratify this agreement in 2020. Countries have some tasks to achieve the main goals of a green economy and a sustainable life. One is carbon neutrality. Many countries have initiated a green transformation in their economies to achieve the goal of zero carbon emissions by 2050, and this transition process continues despite significant challenges. Among the Eurasian countries, Russia and Kazakhstan have targeted 2060 for carbon neutrality. To understand and manage these risks, their exact causes must be determined. Therefore, the abovementioned reasons constitute the main motivation for our study to focus on Eurasia.

Developments in Eurasian countries regarding the variables are summarised in the following paragraph. In this context, Figure A1 presented in the Appendix
section shows the proportional distribution of energy production in Eurasian countries according to their sources in the period 1992-2020. Energy production from fossil sources is dominant in this group of countries. While the share of fossil resources in energy production was 72% in 1992, this rate decreased to 60% in 2020. On the other hand, the share of nuclear energy in energy production has gradually increased, reaching 18.44% in 2020, which was 12% in 1992. While the share of energy obtained from renewable energy sources (including hydroelectricity) was 15.72% in 1992, this rate will reach around 20.65% in 2020. Although the dominant source of energy production in the Eurasian region is fossil resources (oil, natural gas, coal), the decline seen here has been met by energy production from nuclear and renewable sources.

One of the important issues is capital insufficiency, especially for underdeveloped or developing countries. Owing to a lack of capital, these countries have not been able to complete their economic improvement and development. FDI is seen as an important source of external finance for these countries and is the subject of numerous scientific studies because of its positive/negative contributions to the country’s economies. The positive effects of FDI on country economies can emerge through the following channels (Bergougui and Murshed 2023; Serfraz, Qamruzzaman and Karim, 2023; Polloni-Silva et al, 2022; Joo, Shawl and Makine, 2022; Rezk et al, 2022; Vujanović et al., 2022; Dinh et al., 2019). Economic and financial contributions: It can be listed as reducing the volatility in the exchange rate due to the inflow of foreign currency into the country, reducing the balance of payments deficits, increasing employment, increasing exports, reducing imports, increasing tax revenues, increasing productivity, increasing national and international competition, breaking into new markets, and allowing international economic and financial integration. Technological contributions: Enabling technology transfer can be expressed as R&D investments. Managerial and human resource contributions: These include introducing new and updated management processes, providing qualified senior managers, and developing human capital. In this context, the development of FDI inflows is shown in Figure A2 for the period 1992-2021 in Eurasian countries, consisting of underdeveloped and developing countries. As these countries
achieved their independence, FDI inflows increased and reached their peak in 2007-2008 ($77 Billion and $100 Billion, respectively). After the 2008 global economic crisis, there was a decrease in FDI inflows, and the average FDI inflows were approximately $51 Billion in the 2009-2021 period. In addition, the first three countries in the total FDI inflows (as a period average) were Russia with 59.76%, Kazakhstan with 20.86%, and Azerbaijan with 8.71%, respectively among the countries of the region.

This study offers various contributions to the literature. First, it addresses a serious gap by shedding light on the Eurasian COEm issue from different disciplines such as economy, finance, and transportation. Second, the simultaneous panel provides non-parametric evidence for the decisive factors of COEm along the conditional distribution using methods such as quantile regression (QR) and robust quantile regression (Robust-QR).

This study examines the subject in the context of the theoretical discussions in the introduction. The second section provides a brief review of the related literature. The third section describes the model and data used in the empirical analysis. Finally, the results and policy implications are discussed.

2. Literature

There is a large body of literature on the decisive factors of COEm analysing individual economies, countries, or country groups. For example, we can cite studies on China (Shahbaz et al., 2022; Zhao et al., 2022; Pan et al., 2022; Fang et al., 2022; Akram et al., 2022a; Ma, Murshed and Khan, 2021; Xu et al., 2021b; Yu and Zhang, 2021; Wu et al., 2021); on the USA (Yang, Shahzadi and Hussain, 2021; Xiangyu, Jammazi and Aloui, 2021; Sun et al., 2021; Yamaka, Phadkantha and Rakpho, 2021; Dedeoğlu, Koçak and Uucak, 2021); on Turkey (Raihan and Tuspekova, 2022; Yildirim and Yildirim, 2021; Akkaya and Hepsag, 2021); on Pakistan (Huang et al., 2022a; Qudrat-Ullah, 2022; Yousaf, Amin and Baloch, 2021); on India (Akadiri and Adebayo, 2022; Dwivedi and Soni, 2022; Kirikkaleli and Adebayo, 2021); on MINT countries (Adebayo et al., 2022; Du et al., 2022;
Akram et al., 2022b; Joof and Isiksal, 2021); on OECD countries (Albulescu, Boatca-Barabas and Diaconescu, 2022; Cao, Khan and Rehman, 2022; Yang et al., 2021a; Cheng et al., 2021; Zaidi, Hussain and Zaman, 2021); on developing countries (Wang et al., 2022; Çakar et al., 2021); on developed countries (Dong et al., 2022; Tufail, Song and Adebayo, 2021; Ponce and Khan, 2021; Doğan et al., 2020); on G20 countries (Huang, Kuldasheva and Bobojanov, 2022b; D’Orazio and Dirks, 2022; Ajide and Ibrahim, 2021; Habiba, Xinbang and Ahmad, 2021); and on the European Union (EU) (Dechezlepretre, Nachtigall and Venmans, 2023; Bekun et al., 2021; Adedoyin, Alola and Bekun, Alola and Gyamfi, 2021; Radmehr, Henneberry and Shayanmehr, 2021). This study contributes to the empirical literature from the Eurasian perspective.

2.1. Link between COEm and FDIs

FDIs are an important source of external financing, especially in emerging economies. There is extensive literature on them, such as their contributions to economic growth (Djellouli et al., 2022; Iqbal, Tang and Rasool, 2022; Hussain, Bashir and Shahzad, 2021), increasing export performance (Aghasafari et al., 2021; Do et al., 2022; Ajija, Zakia and Purwono, 2021), and reducing unemployment (Mkombe et al., 2021; Ni et al., 2021; Mukit, Abdel-Razzaq and Islam, 2020). However, the association between the environment and FDIs is unclear and is addressed by two antagonistic hypotheses: the PHav hypothesis, which posits that FDIs may have adverse environmental impacts, and the PHal hypothesis, which posits that they have positive impacts (Song, Mao and Han, 2021; Nasir, Huynh and Tram, 2019). In this context, the following studies provide empirical evidence that FDIs increase COEm, and therefore the PHav hypothesis is valid: Abdul-Mumuni, Amoh and Mensah (2023) through the panel NARDL in sub-Saharan Africa for the 1996–2018 period; Balsalobre-Lorente et al. (2022) through the DOLS method in PIIGS countries for 1990–2019; Gyamfi et al. (2022) through OLS and QR methods in E7 countries for 1990–2016; Jijian et al. (2021) through CCEMG and AMG estimation techniques in one generation and one road countries for 1993–2018; Wu, and Zhang (2021) through the spatial Durbin model (SDM) in China for 2003–2017; and finally, Salahodjaev, and Isaeva (2022) through the panel FMOLS and
DOLS methods in post-social states for 1995–2017. However, the following studies provide empirical evidence that FDIs reduce COEm, validating the PHal hypothesis: Abbass et al. (2022) through the ARDL method for the 2000–2020 period in South Asian countries; Abid, Mehmood, and Tariq (2022) using the FMOLS and DOLS methods in G8 countries for 1990–2019; Polloni-Silva et al. (2021) using the LIML technique in Brazil for 2010–2016; Neves, Marques and Patrico (2020) for 1995–2017 in the EU; and Nguyen, Huynh and Nasir (2021) in G6 countries for 1978–2014. FDI-related effects on the environment may vary according to the degree of economic development (Benli and Acar, 2022; Habiba et al., 2021; Kisswani and Zaitouni, 2023; Nguyen, 2021; Benzerrouk, Abid and Sekrafi, 2021; Arif, Arif and Khan, 2022; Shahbaz et al., 2015a) and have been empirically shown to increase emissions in developing economies and decrease emissions in developed economies.

We developed the following hypothesis from the literature summary above, with the countries comprising the study sample considered underdeveloped or developing:

\[ H_1: \text{FDIs have positive and meaningful effects on COEm.} \]

### 2.2. Link Between COEm and ROADpt

Since the Industrial Revolution, rapid socioeconomic growth, financial development, and improved living standards have increased demands on the transportation industry (Khan, Ponce and Yu, 2021a; Hussain et al., 2022; Wang et al., 2018). Transport-related ENCO accounted for 22% and 16%, respectively, of carbon and GHG emissions worldwide in 2019, ranking second after electricity and heating (Ritchie, Roser and Rosado, 2020). Therefore, the transportation sector has been the subject of considerable scientific research because of its impact on climate change. The literature on land transport is summarised as follows. The study by Zhang, Huang and Wu (2022) for BRICS countries covers 1990–2018. Results showed that freight and passenger transport significantly contribute to higher PM 2.5 concentrations, with the effect of freight transport being approximately twice that of passengers. Hussain et al. (2022) investigated the effect of economic
improvement, environmental expenditures, transportation-related COEm, and income inequality on transportation-related COEm for the OECD using panel data for 2000–2020. Results showed that transportation increased transportation-related COEm levels by 46.45%, and the combined impact of economic improvement and environmental taxes reduced transportation-related COEm by 14.70%. Raza, Shah and Sharif (2019) examined the link between transportation-related ENCO and environmental degradation in the United States using the Wavelet method for monthly data between January 1973 and July 2015. Results showed that ENCO increased COEm in the short, medium, and long term. Moreover, the causality test showed unidirectional causality from ENCO to COEm. In a similar study, Andres and Padilla (2018) investigated the effect of the transport industry of several EU-28 countries on GHG emissions using panel data econometric models and the STIRPAT method for 1980–2014. Findings deduced that transport energy density and transport volume are significantly and positively correlated with GHG emissions. There is concurrence in the literature that the transportation sector increases COEm. The findings of studies conducted by Wang et al. (2018) in China, Mustapa and Bekhet (2015) in Malaysia, and Shahbaz, Khraief and Jemaa (2015b) in Tunisia support this consensus.

As the world moves towards lower-carbon sources of electricity, the rise of electric vehicles offers a viable option for reducing emissions from passenger vehicles. In this context, Zhu, Jianguo and Ali (2023) evaluated the transition to sustainable resources and the promotion of green initiatives such as green logistics, green investments, and environmental policies (such as environmental technology and environmental tax) as potential ways to overcome this challenge. They also stated that environmental technology, environmental taxes, and renewable energy will help reduce transportation emissions. In contrast, Li, Sohail and Majeed (2021) revealed that green logistics performance increases economic growth in the One Belt and Road Initiative (OBRI), Europe, and the Middle East and North Africa (MENA) economies. It has also been emphasised that while green logistics performance increases environmental pollution in OBRI, Central Asia, and MENA economies, it significantly increases environmental quality in Europe and East and Southeast Asia.
We developed the following hypothesis in keeping with the theoretical expectations outlined in the literature summary:

\[ H_2: \text{ROADpt has a positive and meaningful effect on COEm.} \]

### 2.3. Link Between COEm and RAILpt

Railways are the most energy-efficient and lowest-emission mode of transport. Despite the freight and passenger traffic it carries, rail accounts for only 2% of the total transport-related energy demand (IEA, 2019b). Studies have shown that RAILpt affects COEm in different ways. For example, Dzator, Acheampong and Dzator (2021) revealed that rail transport infrastructure directly contributed to higher emissions in emerging countries from 1990 to 2018. On the other hand, Abul and Satrovic (2022) underscored the importance of using clean energy in terms of energy efficiency in the transportation sector, while showing that railway transportation increases COEm in Turkey and Croatia, which are among the South-East Europe (SEE) countries. A study by Mu et al. (2022) revealed that the logistics sector in Pakistan caused environmental degradation from 1990 to 2019, when rail transport increased COEm in the short and long term. They mention that the country’s rail system is ageing, and railway engines are inefficient in terms of fuel consumption and maintenance needs, which may account for this scenario. In another study specific to Pakistan, Sohail et al. (2021) concluded that positive shocks in RAILpt increased long-term COEm from 1991 to 2019. On the other hand, studies have shown that rail transport reduces COEm, the argument being that demand for road and air transportation decreases with the introduction of high-speed trains because they are faster, safer, and cheaper. Zhou, Xu and Tao (2022), Sun and Li (2021), Strauss, Li and Cui (2021), Tang, Mei and Zou (2021), Lin, Qin and Wu (2021), and Jia, Shao and Yang (2021) provide empirical evidence supporting this result.

We developed the following hypothesis in keeping with the theoretical expectations outlined in the literature summary:

\[ H_3: \text{RAILpt has a meaningful effect on COEm.} \]
2.4. Link between COEm and GDP

Although economic expansion greatly increases public welfare, this growth seriously affects environmental quality (Djellouli et al., 2022). Increasing greenhouse gas emissions (GHGs) primarily caused environmental degradation. Energy consumption caused these emissions, too through the fossil fuels used in various economic activities (Beton Kalmaz and Awosusi 2022). This part of the study includes studies on the effects of economic growth (GDP) on COEm. Kirikkaleli, Awosusi and Adebayo (2023) examined the effect of COEm intensity on GDP, energy consumption, renewable energy, and economic growth on CO2 emissions in Portugal. The nonlinear autoregressive distributed lag (NARDL) method was used in the analysis of data for the period 1990-2019. According to the results, a positive change in energy consumption positively affects COEm, whereas a negative shock in energy consumption has a neutral effect on COEm. Additionally, it is revealed that positive/negative shocks of economic growth and COEm intensity of GDP increase/decrease environmental degradation by increasing/decreasing COEm. Abbasi, Kirikkaleli and Altuntaş (2022) investigated the effect of COEm intensity of GDP on COEm in Turkiye. The NARDL method was used in the analysis of data for the years 1990-2018. According to the results, they found that both economic development (GDP) and the increase in carbon intensity increased COEm. Chen et al. (2022) examined the interaction between GDP and COEm in China. They used the QARDL method in analysing data for the period 1990-2020. According to their results, GDP positively affects COEm in China. Similarly, Adebayo (2023) and Xie et al. (2022) in China, Qayyum et al. (2022) in India, Adeshola et al. (2022) in Portugal, Ahmed et al. (2021) in G7 countries, Sikder et al. (2022) in developing economies, and Yu et al. (2022) in 25 developing economies reveal that there is a positive and significant connexion between GDP and COEm. In contrast, Acheampong, Dzator and Amponsah (2022) analysed data for Australia for the period 1970-2018 using the NARDL approach, and according to the results, they found that increases and decreases in GDP had an insignificant effect on COEm. In this regard, we developed the following hypothesis in keeping with the theoretical expectations outlined in the literature summary above:

\[ H_4: \text{GDP per capita has a meaningful effect on COEm.} \]
3. Methodology

3.1. Data

The sample of the study consists of eight Eurasian countries (Russia, Kazakhstan, Uzbekistan, Turkmenistan, Azerbaijan, Georgia, Kyrgyzstan, and Tajikistan)\(^1\) using data from 1992 to 2020. Because these countries achieved their independence after the collapse of the USSR in December 1991, pre-1992 data were not available. The data series with their nominal values were included in the analysis. For some years, the dataset exhibited an unbalanced panel data structure because the number of observations was missing. The data are presented in Table 1.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Definition</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>COEm</td>
<td>It covers carbon dioxide emissions from coal, oil, gas use (combustion and industrial processes), and gas combustion and cement manufacture. Expressed in metric tonnes (MtCO(_2)).</td>
<td><a href="http://www.globalcarbonatlas.org">www.globalcarbonatlas.org</a></td>
</tr>
<tr>
<td>FDI</td>
<td>Foreign Direct Investment, net inflows (US$)</td>
<td><a href="http://www.worldbank.org">www.worldbank.org</a></td>
</tr>
<tr>
<td>RAILpt</td>
<td>Number of passengers transported by rail per km (Millions)</td>
<td><a href="http://www.oecd.org">www.oecd.org</a></td>
</tr>
<tr>
<td>ROADpt</td>
<td>Number of passengers transported by road per km (Millions)</td>
<td><a href="http://www.oecd.org">www.oecd.org</a></td>
</tr>
<tr>
<td>PGDP</td>
<td>GDP per capita (US$)</td>
<td><a href="http://www.worldbank.org">www.worldbank.org</a></td>
</tr>
</tbody>
</table>

3.2. Method

The QR method, a non-parametric technique, was preferred in this study because the data did not show a normal distribution. Additional reasons to use this method are as follows: QR allows the model to consider outliers and search for determinants of the response variable throughout the conditional distribution compared with the OLS method, which is more precise to outliers. Regression

\(^1\) There is no consensus in international organisations regarding which countries are Eurasian countries. For example, the United Nations considers 14 countries, the OECD considers 13 countries, and the International Energy Agency (IEA) considers 9 countries as Eurasian countries. In this study, the classification made by the IEA was considered.
coefficients obtained using the OLS method were calculated using the mean function. However, the different coefficients calculated for each quantile level in QR reflect the dissimilar effects of the conditional distribution of the response variable. In other words, the QR model is appropriate when the factors involved have dissimilar impacts at several points in the conditional distribution of the response factor (Belaid, Elsayed and Omri, 2021; Alvarado et al., 2021). In addition, the residuals of the QR model do not need to meet the classical assumptions of OLS (Opoku and Aluko, 2021). Therefore, the QR method provides more powerful and effective econometric consequences by estimating the heterogeneous impacts of the explanatory variables on the response variable (Bilgili et al., 2022).

The QR model can be mathematically represented as follows (Maji and Saha, 2021):

\[
y_i = x_i \beta + \varepsilon_i, ...
\]

\[
Q_\tau(y_i | x_i) = x_i^\tau \beta, ...
\]  

(1)

Here, \( \beta^\tau \) represents the error term that satisfies the condition. For the panel data, the model can be mathematically represented as follows:

\[
Y_{it} = \alpha + \beta_{1,t}X_{1it} + \beta_{2,t}X_{2it} + \ldots + \beta_{m,t}X_{mit} + \varepsilon_{it}
\]

(2)

where \( i \) is the unit of country (\( i = 1, 2, \ldots, N \)) and \( t \) represents year (\( t = 1, 2, \ldots, T \)). The model simultaneously calculates the coefficient estimates at different quantile levels using the following minimisation approach:

\[
\min_{(\alpha, \beta)} \sum_{k=1}^{q} \sum_{i=1}^{T} \sum_{i=1}^{n} w_k \rho_\tau(y_{it} - \alpha - x_{it}^\tau \beta_{it})
\]

(3)

This study used a simultaneous QR estimation model to test whether the coefficients were similar at the conditional quantile levels. Simultaneous QR is a powerful econometric technique that explains the non-normal distribution of error terms and varying variances. The standard errors of the coefficients are estimated using the bootstrap method in the simultaneous QR model, and the
inter-quantile variance-covariance matrix is obtained (Ercan, 2021; Delisi et al., 2011). On the basis of the above notation, we can express the simultaneous QR model with fixed effects for panel data as follows:

\[
Q_i(COEm_i, FDI_{i,j}, RAILpt_{i,j}, ROADpt_{i,j}, PGDP_{i,j}) = \alpha_i + \beta_{1,1}FDI_{i,j} + \beta_{1,2}RAILpt_{i,j} + \beta_{1,3}ROADpt_{i,j} + \beta_{1,4}PGDP_{i,j}\epsilon_{ij}
\] 

(4)

The Hausman test was performed to determine the most suitable econometric feature, and the fixed-effects model was preferred for the Chi-Square statistic (110.83) considering a p value=0.000.

4. Analysis Results and Findings

4.1. Basic Statistical Tests and Correlation Analysis

Basic statistical tests and their results are shown in Panel A of Table 2. These were performed to explain and define the basic/key features of the series. The results of the correlation analysis were carried out to understand the direction and size of the connexions between the variables. They are shown in Panel B of Table 2.

| Table 2: Basic statistical tests and correlation analysis |
|-----------------|--------|--------|--------|--------|
|                 | COEm  | FDI    | RAILpt | ROADpt |
| Mean            | 255.574 | 4.20E+09 | 38541.60 | 70775.10 |
| Median          | 37.022   | 6.91E+08 | 2100.000  | 24657.50 |
| Maximum         | 1957.886 | 7.48E+10 | 272167.0  | 260581.0 |
| Minimum         | 1.877    | -4.02E+08 | 172.000   | 954.000  |
| Std. Dev.       | 517.852  | 1.07E+10 | 68126.57  | 73896.69 |
| Skewness        | 2.210    | 4.267    | 1.605    | 0.788   |
| Kurtosis        | 6.089    | 22.609   | 4.187    | 2.294   |
| Jarque-Bera     | 281.168  | 4345.380 | 63.452   | 16.155  |
| Probability     | 0.000    | 0.000    | 0.000    | 0.000   |

Panel B: Correlation Analysis

<table>
<thead>
<tr>
<th></th>
<th>COEm</th>
<th>FDI</th>
<th>RAILpt</th>
<th>ROADpt</th>
<th>PGDP</th>
</tr>
</thead>
<tbody>
<tr>
<td>COEm</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FDI</td>
<td>0.604</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RAILpt</td>
<td>0.968</td>
<td>0.521</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ROADpt</td>
<td>0.675</td>
<td>0.381</td>
<td>0.669</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>PGDP</td>
<td>0.451</td>
<td>0.695</td>
<td>0.338</td>
<td>0.535</td>
<td>1</td>
</tr>
</tbody>
</table>
According to the JB test statistic results in Table 2, none of the variables showed a normal distribution. The dataset has an unbalanced panel feature because of the difference in the number of observations. The correlation coefficients showed a positive correlation between the response and exposure variables. These findings shed light on method selection, analysis results, and hypothesis development.

### 4.2. Stationarity Analysis

Before checking the stationary characteristics of the variables for carbon emissions, rail passenger transport, road passenger transport, and FDIs, each panel series had to be investigated for cross-sectional dependence (CSD). Because this study was based on panel data, there was a high possibility of cross-sectional dependence. This may occur because of spatial or diffuse effects or unobserved co-factors. Ignoring the existence of CSD may affect the objectivity and consistency of classic panel estimators (Usman et al., 2022; Rahman, Nepal and Alam, 2021; Cheng and Yao, 2021; Zafar et al., 2021).

<table>
<thead>
<tr>
<th>Variables</th>
<th>Breusch-Pagan LM test</th>
<th>Pesaran CD test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Test statistic</td>
<td>Test statistic</td>
</tr>
<tr>
<td>COEm</td>
<td>307.285 (0.000) ***</td>
<td>11.632 (0.000) ***</td>
</tr>
<tr>
<td>FDI</td>
<td>254.502 (0.000) ***</td>
<td>15.182 (0.000) ***</td>
</tr>
<tr>
<td>RAILpt</td>
<td>81.728 (0.000) ***</td>
<td>7.498 (0.000) ***</td>
</tr>
<tr>
<td>ROADpt</td>
<td>170.781 (0.000) ***</td>
<td>3.033 (0.002) ***</td>
</tr>
<tr>
<td>PGDP</td>
<td>715.377 (0.000) ***</td>
<td>26.724 (0.000) ***</td>
</tr>
</tbody>
</table>

Note: Significance level; *** %1

According to the CSD test results in Table 3, CSD was found for all variables, indicating that second-generation unit root tests are mandatory to check the stationarity of the series. For this purpose, the PANIC test suggested by Bai and Ng (2004), which allows the analysis of both observed variables and common
factors, was used (Esen, Yıldırım and Yıldırım, 2021; Çakar et al., 2021; Tayebi, Önel and Moss, 2021). Another feature is that the tests for factors and specific errors do not depend on whether the error term is I(0) or I(1) (Barbieri, 2009). This test also offers strong statistical results in the case of cross-correlations (Yang, Ali and Hashmi, 2022; Erdogan, 2021). In other words, the space occupied by unobserved joint elements and idiosyncratic disorders allows consistent prediction without knowing whether they are static or integrated into the PANIC approach (Gengenbach, Palm and Urbain, 2009). Additionally, these test statistics are suitable for balanced and unbalanced data and can handle missing values (Yang et al., 2022; Milanez, 2020). The PANIC test results are shown in Table 4.

<table>
<thead>
<tr>
<th>Variables</th>
<th>test statistics</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>COEm</td>
<td>3.759</td>
<td>(0.000)** ***</td>
</tr>
<tr>
<td>FDI</td>
<td>6.434</td>
<td>(0.000)** ***</td>
</tr>
<tr>
<td>RAILpt</td>
<td>1.863</td>
<td>(0.068)*</td>
</tr>
<tr>
<td>ROADpt</td>
<td>-2.209</td>
<td>(0.027)**</td>
</tr>
<tr>
<td>PGDP</td>
<td>-1.890</td>
<td>(0.058)*</td>
</tr>
</tbody>
</table>

Note: Significance Level; ***%1, **%5, *%10

Results show that all series were stationary in the model with constant level values. Therefore, these variables can be used in regression analyses according to their level values.

4.3. Results of the Simultaneous PQR Analysis

The results of the simultaneous PQR analysis performed to estimate the effects of different levels of FDI, RAILpt, ROADpt, and PGDP on COEm in Eurasian countries are shown in Table 5. The impact of explanatory variables on COEm was estimated for nine quantile levels (10, 20, 30,…,90).
The results show that FDI inflows have a positive and significant impact on COEm in Eurasian countries, and this effect is particularly significant at all quintile levels except quintiles 8 and 9. Therefore, although FDIs are an important source of external financing, they cause environmental pollution in Eurasian countries. According to the theoretical background, PHav is said to be valid for the period examined in this example. A reason for this situation is that the region is rich in fossil resources, which attracts the attention of foreign investors. The impact of GDP per capita on COEm is heterogeneous and significant only at the 5th quartile. Therefore, a clear picture of the effect of this variable on the dependent variable could not be obtained. Additionally, transportation infrastructure had a positive and significant impact on COEm in this sample group. RAILpt had a positive impact on COEm at all quintile levels, and this impact trended upward. ROADpt also had a significant impact on COEm; this was especially true for low and medium quintile levels. Note that the sample countries belong to the former USSR, and the main means of transport for both freight and passengers is rail; however, the fact that the trains are outdated and run on old technology explains why railway is the highest contributor to COEm. It is also worth noting that the
effect of the independent variables on the dependent variable is close to zero and therefore quite limited.

Table 6: Testing for slope heterogeneity

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta$</td>
<td>3.898***</td>
<td>10.815***</td>
</tr>
<tr>
<td>$\Delta_{adj}$</td>
<td>4.465***</td>
<td>12.390***</td>
</tr>
</tbody>
</table>

Note: Significance level, ***%1

The test statistics were significant at the 1% significance level (Table 6). Therefore, the $H_0$ hypothesis, which states that the slope is homogeneous across quantities, is rejected. This result provides evidence that the connexion between endogenous and exogenous variables varies across several quantities.

4.4. Robustness Check

At this stage, the validity of the findings obtained from the simultaneous PQR analysis was tested using the Robust QR model to capture the unobserved distributional heterogeneity among economies within a panel. This technique can produce robust and reliable estimates even in the presence of outliers (John, 2015; John and Enduka, 2009). These results are presented in Table 7.

The results of the Robust-QR method applied to support the results of simultaneous PQR analysis, which is the basic method, are given in Table 7. In particular, the results obtained for FDI, RAILpt, and ROADpt largely overlap with the findings of the basic analysis method. Therefore, we have obtained solid empirical evidence to identify issues affecting COEm in Eurasian countries.

5. Conclusions and Recommendations

A better understanding of the key factors affecting environmental quality is essential for the implementation of policies that successfully reduce emissions. This study conducted analyses within the framework of QR methods to examine the heterogeneous effects of FDIs and road and rail passenger transport COEm in
a sample of eight Eurasian countries between 1992 and 2020. Transport-based indicators and financial variables such as FDI, which are frequently used in the empirical literature, were chosen to more comprehensively consider factors affecting COEm. Therefore, the inclusion of relevant indicators adds a unique dimension to this study focussing on Eurasia. After the preliminary tests, the simultaneous PQR method was used as the main analysis method. To test the robustness of the findings, analyses were carried out within the framework of the Robust-QR method. Three important results were obtained: 1) The impact of FDIs on COEm at low and medium quantile levels is statistically significant and positive. Therefore, FDIs in Eurasian countries increase COEm, making the PHav hypothesis valid for Eurasian economies. 2) The effect of rail transport on COEm is statistically significant and positive at all quantile levels, and it tends to increase. Therefore, the impact of rail transport on COEm is heterogeneous. The main reason for this is the widespread use of diesel locomotives with old technology. In addition, it is seen that the railways cannot be used effectively and the capacity utilisation rate decreases due to the widespread use of diesel locomotives with old technology. 3) The impact of PGDP on COEm is statistically significant and negative at all quantile levels, and it tends to decrease. Therefore, the effect of economic growth on COEm is negative. This result suggests that economic growth can be a factor in reducing COEm.

Table 7: Results of robust QR (ROBREG)

<table>
<thead>
<tr>
<th>Variable</th>
<th>10</th>
<th>20</th>
<th>30</th>
<th>40</th>
<th>50</th>
<th>60</th>
<th>70</th>
<th>80</th>
<th>90</th>
</tr>
</thead>
<tbody>
<tr>
<td>FDI</td>
<td>0.000 (0.013)**</td>
<td>0.000 (0.052)*</td>
<td>0.000 (0.199)</td>
<td>0.000 (0.257)</td>
<td>0.000 (0.002)**</td>
<td>0.000 (0.003)**</td>
<td>0.000 (0.000)**</td>
<td>0.000 (0.774)</td>
<td>-0.000 (0.882)</td>
</tr>
<tr>
<td>RAILpt</td>
<td>0.006 (0.000)**</td>
<td>0.007 (0.000)**</td>
<td>0.008 (0.000)**</td>
<td>0.008 (0.000)**</td>
<td>0.008 (0.000)**</td>
<td>0.008 (0.000)**</td>
<td>0.010 (0.000)**</td>
<td>0.011 (0.000)**</td>
<td></td>
</tr>
<tr>
<td>ROADpt</td>
<td>0.000 (0.010)**</td>
<td>0.000 (0.010)**</td>
<td>0.000 (0.001)**</td>
<td>0.000 (0.001)**</td>
<td>0.000 (0.001)**</td>
<td>0.000 (0.001)**</td>
<td>0.000 (0.000)**</td>
<td>-0.000 (0.609)</td>
<td>-0.000 (0.069)*</td>
</tr>
<tr>
<td>PGDP</td>
<td>-0.001 (0.658)</td>
<td>-0.001 (0.547)</td>
<td>-0.002 (0.600)</td>
<td>-0.002 (0.563)</td>
<td>-0.004 (0.336)</td>
<td>-0.004 (0.318)</td>
<td>-0.005 (0.224)</td>
<td>0.009 (0.347)</td>
<td>0.013 (0.121)</td>
</tr>
<tr>
<td>C</td>
<td>-1.000 (0.926)</td>
<td>0.871 (0.941)</td>
<td>5.187 (0.661)</td>
<td>7.068 (0.558)</td>
<td>16.362 (0.188)</td>
<td>21.637 (0.049)**</td>
<td>33.772 (0.002)**</td>
<td>75.039 (0.000)**</td>
<td>101.656 (0.000)**</td>
</tr>
<tr>
<td>Pseudo R²</td>
<td>0.736</td>
<td>0.759</td>
<td>0.782</td>
<td>0.805</td>
<td>0.823</td>
<td>0.841</td>
<td>0.861</td>
<td>0.865</td>
<td>0.839</td>
</tr>
</tbody>
</table>

Note: Significance level: ***1%, ** 5%, *10%
to the decrease in the number of passengers carried over the years. This indicates that passengers do not prefer railways.

3) The effect of ROADpt on COEm is significant and positive at low and medium quantile levels; The main reason for this is the extensive and intensive exploitation of fossil resources in Eurasian countries. 4) No clear result could be obtained regarding the role of PGDP on the dependent variable. This result shows that, on average, per capita income is quite low in the countries of the region; therefore, consumption preferences are not sufficient to increase/decrease carbon emissions.

These results offer important implications for investors and political decision makers. These countries offer valuable opportunities to investors, especially in terms of renewable energy investments, which can be facilitated by legislation that encourages foreign capital inflow. Steps should be taken towards financial liberalisation and their implementation should be encouraged. In terms of public services, old railway transportation technologies need to be replaced with environmentally friendly systems. Rail transport can only reduce emissions when the fuel source is electricity and its use is more widespread; This can be achieved by increasing population awareness and effective tariffs. In this context, every aspect of the travel experience needs to be improved, from the time cargo leaves warehouses and passengers leave their homes to their safe arrival at their destination, through policies yet to be established. To achieve this, the entire end-to-end journey must be examined. Rehabilitating the transportation infrastructure, especially in a way that protects the environment, will make travel more comfortable for both freight and passengers and will contribute to the creation of economies of scale, which is one of the main purposes of transportation systems. Thus, creating economic, social, and environmental benefits can achieve sustainability.

The most important limitation of this research is that the data regarding railway and road transportation are not regular. If these data are more organised, the findings and results of the research may be more meaningful.
Contribution of Finance and Transport Indicators on Carbon Emissions: Evidence from Eurasian Countries

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References


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APPENDIX

Figure A1. Energy Production by Source in Eurasian Region

Source: Prepared by the authors using data published by the International Energy Agency (IEA).

Figure A2. FDI inflow ($) in Eurasia Region

Source: Prepared by the authors using data published by the World Bank.