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RESEARCH ARTICLE

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

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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, 2019a). 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 (Rodrigue, 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, 2021b; 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; Yıldırım and Yıldırım, 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: 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: 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: 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: 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 1: Description of variables

Variable	Definition	Source
COEm	It covers carbon dioxide emissions from coal, oil, gas use (combustion and industrial processes), and gas combustion and cement manufacture. Expressed in metric tonnes ($MtCO_2$).	www.globalcarbonatlas.org
FDI	Foreign Direct Investment, net inflows (US$)	www.worldbank.org
RAILpt	Number of passengers transported by rail per km (Millions)	www.oecd.org
ROADpt	Number of passengers transported by road per km (Millions)	www.oecd.org
PGDP	GDP per capita (US$)	www.worldbank.org

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):

$$y_i = x_i^{'}\beta_\tau + \varepsilon_i^\tau \ldots$$
$$Q_\tau(y_i \mid x_i) = x_i^\tau \beta_\tau \ldots \quad (1)$$

Here,β_τ ; τ'th estimated coefficient for QR ((0<τ<1) and ε_i^τ ; $Q_\tau(\varepsilon_i^\tau \mid x_i)$ represents the error term that satisfies the condition. For the panel data, the model can be mathematically represented as follows:

$$Y_{i,t} = \alpha_i + \beta_{\tau,1}X_{i,t}^1 + \beta_{\tau,2}X_{i,t}^2 + \ldots + \beta_{\tau,m}X_{i,t}^m + \varepsilon_{i,t}^\tau \quad (2)$$

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

$$\min_{(\alpha,\beta)} \sum_{k=1}^{q}\sum_{t=1}^{T}\sum_{i=1}^{n} w_k \rho_{\tau_k}(y_{it} - \alpha_i - x_{it}^{'}\beta_{\tau_k})\ldots \quad (3)$$

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:

$$Q_{\tau}(COEm_{i,t} \mid FDI_{i,t}, RAILpt_{i,t}, ROADpt_{i,t}, PGDP_{i,t}) = \alpha_i + \beta_{\tau,1}FDI_{i,t} + \beta_{\tau,2}RAILpt_{i,t} + \beta_{\tau,3}ROADpt_{i,t} + \beta_{\tau,4}PGDP_{i,t}\varepsilon_{i,t}^{\tau} \quad (4)$$

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	PGDP
Mean	255.574	4.20E+09	38541.60	70775.10	3013.181
Median	37.022	6.91E+08	2100.000	24657.50	1308.140
Maximum	1957.886	7.48E+10	272167.0	260581.0	15974.64
Minimum	1.877	-4.02E+08	172.000	954.000	60.458
Std. Dev.	517.852	1.07E+10	68126.57	73896.69	3508.127
Skewness	2.210	4.267	1.605	0.788	1.627
Kurtosis	6.089	22.609	4.187	2.294	4.959
Jarque-Bera	281.168	4345.380	63.452	16.155	138.870
Probability	0.000	0.000	0.000	0.000	0.000
Panel B: Correlation Analysis					
COEm	1				
FDI	0.604	1			
RAILpt	0.968	0.521	1		
ROADpt	0.675	0.381	0.669	1	
PGDP	0.451	0.695	0.338	0.535	1

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 3: CSD test results

	Breusch-Pagan LM test	**Pesaran CD test**
Variables	Test statistic	Test statistic
COEm	307.285 (0.000) ***	11.632 (0.000) ***
FDI	254.502 (0.000) ***	15.182 (0.000) ***
RAILpt	81.728 (0.000) ***	7.498 (0.000) ***
ROADpt	170.781 (0.000) ***	3.033 (0.002) ***
PGDP	715.377 (0.000)***	26.724 (0.000)***

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 4: Bai and Ng-PANIC test results

	Level	
Variables	test statistics	p-value
COEm	3.759	(0.000)***
FDI	6.434	(0.000)***
RAILpt	1.863	(0.068)*
ROADpt	-2.209	(0.027)**
PGDP	-1.890	(0.058)*

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).

Table 5: Results of the Simultaneous PQR Analysis

	Quantile Levels								
	10	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**
FDI	0.000 (0.005) ***	0.000 (0.013) **	0.000 (0.083) *	0.000 (0.027) **	0.000 (0.007) ***	0.000 (0.025) **	0.000 (0.056) *	0.000 (0.811)	0.000 (0.880)
RAILpt	0.006 (0.000) ***	0.007 (0.000) ***	0.007 (0.000) ***	0.008 (0.000) ***	0.008 (0.000) ***	0.008 (0.000) ***	0.008 (0.000) ***	0.010 (0.000) ***	0.011 (0.000) ***
ROADpt	0.000 (0.003) ***	0.000 (0.000) ***	0.000 (0.001) ***	0.000 (0.000) ***	0.000 (0.000) ***	0.000 (0.000) ***	0.000 (0.032) **	-0.000 (0.709)	-0.000 (0.308)
PGDP	-0.001 (0.544)	-0.001 (0.245)	-0.002 (0.263)	-0.002 (0.212)	-0.004 (0.034)**	-0.004 (0.121)	-0.005 (0.520)	0.009 (0.424)	0.013 (0.469)
C	-1.000 (0.698)	0.871 (0.844)	5.187 (0.443)	7.068 (0.389)	16.362 (0.026)**	21.637 (0.011) **	33.772 (0.020) **	75.039 (0.000) ***	101.656 (0.000) ***
Pseudo R^2	0.736	0.759	0.782	0.805	0.823	0.841	0.861	0.865	0.839

Note: Significance level: ***1%, ** 5%, *10%

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 quantile levels, and this impact trended upward. ROADpt also had a significant impact on COEm; this was especially true for low and medium quantile 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

	Pesaran, Yamagata (2008) Testi	Blomquist, Westerlund (2013) Testi
Δ	3.898***	10.815***
$\Delta_{adj.}$	4.465***	12.390***

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

Table 7: Results of robust QR (ROBREG)

Variable	Quantile Levels								
	10	20	30	40	50	60	70	80	90
FDI	0.000 (0.013)**	0.000 (0.052)*	0.000 (0.199)	0.000 (0.257)	0.000 (0.002)**	0.000 (0.003)***	0.000 (0.000)***	0.000 (0.774)	-0.000 (0.882)
RAILpt	0.006 (0.000)000	0.007 (0.000)***	0.007 (0.000)***	0.008 (0.000)***	0.008 (0.000)***	0.008 (0.000)***	0.008 (0.000)***	0.010 (0.000)***	0.011 (0.000)***
ROADpt	0.000 (0.010)***	0.000 (0.000)***	0.000 (0.001)***	0.000 (0.000)***	0.000 (0.001)***	0.000 (0.000)***	0.000 (0.000)***	-0.000 (0.609)	-0.000 (0.069)*
PGDP	-0.001 (0.658)	-0.001 (0.547)	-0.002 (0.600)	-0.002 (0.563)	-0.004 (0.336)	-0.004 (0.318)	-0.005 (0.224)	0.009 (0.347)	0.013 (0.121)
C	-1.000 (0.926)	0.871 (0.941)	5.187 (0.661)	7.068 (0.558)	16.362 (0.188)	21.637 (0.049)**	33.772 (0.002)***	75.039 (0.000)***	101.656 (0.000)***
Pseudo R^2	0.736	0.759	0.782	0.805	0.823	0.841	0.861	0.865	0.839

Note: Significance level: ***1%, ** 5%, *10%

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 RAILpt 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 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. I 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.

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References

Abbass, Kashif., Song, H., Mushtaq, Z., & Khan, F. (2022). Does technology innovation matter for environmental pollution? Testing the pollution halo/haven hypothesis for Asian countries. *Environmental Science and Pollution Research,* 29, 89753-89771. https://doi.org/10.1007/s11356-022-21929-w

Abbasi, K. R, Kirikkaleli, D., & Altuntaş, M. (2022). Carbon dioxide intensity of GDP and environmental degradation in an emerging country. *Environmental Science and Pollution Research*, 29, 84451-84459. https:// doi. org/ 10. 1007/s11356- 022- 21679-9

Abid, A., Mehmood, U., & Tariq, S. (2022). The effect of technological innovation, FDI, and financial development on CO_2 emission: Evidence from the G8 countries. *Environmental Science and Pollution Research,* 29, 11654-11662. https://doi.org/10.1007/s11356-021-15993-x

Abul, S. J., & Satrovic, E. (2022). Revisiting the environmental impacts of railway transport: Does EKC exist in South-Eastern Europe? *Polish Journal of Environmental Studies*, 31(1), 1-11. https://doi.org/10.15244/pjoes/141329

Abdul-Mumuni, A., Amoh, J. K., & Mensah, B. D. (2023). Does foreign direct investment asymmetrically influence carbon emissions in sub-Saharan Africa? Evidence from nonlinear panel ARDL approach. *Environmental Science and Pollution Research,* 30, 11861-11872. https://doi.org/10.1007/s11356-022-22909-w

Acheampong, A. O., Dzator, J., & Amponsah, M. (2022). Analyzing the role of economic globalization in achieving carbon neutrality in Australia. *International Journal of Sustainable Development & World Ecology,* 6, 559-578. https://doi.org/ 10.1080/ 13504 509. 2022. 20567 71

Adebayo, T.S. (2023). Trade-off between environmental sustainability and economic growth through coal consumption and natural resources exploitation in China: New policy insights from wavelet local multiple correlation. *Geological Journal*, 4(5), 12–25. https://doi.org/ 10. 1002/ gj. 4664

Adebayo, T. S., Awosusi, A. A., Rjoub, H., Agyekum, E. B., & Kirikkaleli, D. (2022). The influence of renewable energy usage on consumption-based carbon emissions in MINT economies. *Heliyon*, 8(2), 08941. https://doi.org/10.1016/j.heliyon.2022.e08941

Adedoyin, F. F., Alola, A. A., & Bekun, F. V. (2021). The alternative energy utilization and common regional trade outlook in EU-27: Evidence from common correlated effects. *Renewable and Sustainable Energy Reviews,* 145, 111092. https://doi.org/10.1016/j.rser.2021.111092

Adeshola, I., Adebayo, T. S., Oladipupo, S. D., & Rjoub, H. (2022). Wavelet analysis of impact of renewable energy consumption and technological innovation on CO2 emissions: Evidence from Portugal. *Environmental Science and Pollution Research,* 29(16), 23887–23904. https://doi.org/10.1007/ s11356- 021- 17708-8

Aghasafari, H., Aminizadeh, M., Karbasi, Alireza., & Calisti, R. (2021). CO_2 emissions, export and foreign direct investment: Empirical evidence from Middle East and North Africa Region, *The Journal of International Trade & Economic Development,* 30(7), 1054-1076, https://doi.org/10.1080/09638199.2021.1934087

Ahmed, Z., Ahmad, M., Rjoub, H., Kalugina, O. A., & Hussain, N. (2021). Economic growth, renewable energy consumption, and ecological footprint: exploring the role of environmental regulations and democracy in sustainable development. *Sustainable Development*, 30(4), 595-605. https://doi.org/10.1002/ sd. 2251

Ajide, K.B., & Ibrahim, R.L. (2021). Threshold effects of capital investments on carbon emissions in G20 economies. *Environmental Science and Pollution Research,* 28, 39052–39070. https://doi.org/10.1007/s11356-021-13046-x

Ajija, S. R., Zakia, A. F., & Purwono, R. (2021). The impact of opening the export promotion agencies on Indonesia's non-oil and gas exports. *Heliyon*. 7, 07756. https://doi.org/10.1016/j.heliyon.2021.e07756

Akadiri, S.S., & Adebayo, T.S. (2022). Asymmetric nexus among financial globalization, non-renewable energy, renewable energy use, economic growth, and carbon emissions: impact on environmental sustainability targets in India. *Environmental Science and Pollution Research*, 29, 16311-16323. https://doi.org/10.1007/s11356-021-16849-0

Akkaya, Ş., & Hepsag, A. (2021). Does fuel tax decrease carbon dioxide emissions in Turkey? Evidence from an asymmetric nonlinear cointegration test and error correction model. *Environmental Science and Pollution Research*, 28, 35094-35101. https://doi.org/10.1007/s11356-021-12907-9

Akram, R., Fareed, Z., Xiaoli, G., Zulfiqar, B., & Shahzad, F. (2022a). Investigating the existence of asymmetric environmental Kuznets curve and pollution haven hypothesis in China: Fresh evidence from QARDL and quantile Granger causality. *Environmental Science and Pollution Research*, 29, 50454-50470. https://doi.org/10.1007/s11356-022-18785-z

Akram, R., Umar, M., Xiaoli, G., & Chen, F. (2022b). Dynamic linkages between energy efficiency, renewable energy along with economic growth and carbon emission. A case of MINT countries an asymmetric analysis. *Energy Reports,* 8, 2119-2130. https://doi.org/10.1016/j.egyr.2022.01.153

Albulescu, C.T., Boatca-Barabas, M. E., & Diaconescu, A. (2022). The asymmetric effect of environmental policy stringency on CO_2 emissions in OECD countries. *Environmental Science and Pollution Research*, 29, 27311-27327. https://doi.org/10.1007/s11356-021-18267-8

Alvarado, R., Tillaguango, B., Dagar, V., Ahmad, M., Işık, C., Mendez, P., & Toledo, E. (2021). Ecological footprint, economic complexity and natural resources rents in Latin America: Empirical evidence using quantile regressions. *Journal of Cleaner Production*, 318, 128585. https://doi.org/10.1016/j.jclepro.2021.128585

Andres, L., & Padilla, E. (2018). Driving factors of GHG emissions in the EU transport activity. *Transport Policy*, 61, 60–74. https://doi.org/10.1016/j.tranpol.2017.10.008

Apergis, N., Pinar, M., & Unlu, E. (2022). How do foreign direct investment flows affect carbon emissions in BRICS countries? Revisiting the pollution haven hypothesis using bilateral FDI flows from OECD to BRICS countries, *Environmental Science and Pollution Research*, 30, 14680-14692. https://doi.org/10.1007/s11356-022-23185-4

Arif, U., Arif, A., & Khan, F.N. (2022). Environmental impacts of FDI: evidence from heterogeneous panel methods. *Environmental Science and Pollution Research*, 29, 23639–23649. https://doi.org/10.1007/s11356-021-17629-6

Bai, J., & Ng, S. (2004). A Panic Attack on Unit Roots and Cointegration. *Econometrica*, 72, 1127-1177. https://doi.org/10.1111/j.1468-0262.2004.00528.x

Balsalobre-Lorente D., Ibanez-Luzon, L., Usman M., & Shahbaz, M. (2022). The environmental Kuznets curve, based on the economic complexity, and the pollution haven hypothesis in PIIGS countries. *Renewable Energy*, 185, 1441-1455. https://doi.org/10.1016/j.renene.2021.10.059

Bandyopadhyay, A., & Rej, S. (2021). Can nuclear energy fuel an environmentally sustainable economic growth? Revisiting the EKC hypothesis for India. *Environmental Science and Pollution Research,* 28, 63065-63086 https://doi.org/10.1007/s11356-021-15220-7

Barbieri, L. (2009). Panel unit root tests under cross-sectional dependence: An overview. *Journal of Statistics: Advances in Theory and Applications*, 1(2), 117-158.

Bashir, M. F. (2022). Discovering the evolution of Pollution Haven Hypothesis: A literature review and future research agenda. *Environmental Science and Pollution Research*, 29, 48210-48232. https://doi.org/10.1007/s11356-022-20782-1

Batmunkh, A., Nugroho, A., D., Farkas, M.F., & Lakner, Z. (2022). Global challenges and responses: Agriculture, economic globalization, and environmental sustainability in Central Asia. *Sustainability*, 14, 3-21. https://doi.org/10.3390/su14042455

Bekun, F.V., Alola, A.A., & Gyamfi, B.A. (2021). The relevance of EKC hypothesis in energy intensity real-output trade-off for sustainable environment in EU-27. *Environmental Science and Pollution Research,* 28, 51137-51148. https://doi.org/10.1007/s11356-021-14251-4

Belaid, F., Elsayed, A.H., & Omri, A. (2021). Key drivers of renewable energy deployment in the MENA Region: Empirical evidence using panel quantile regression. *Structural Change and Economic Dynamics*, 57, 225-238. https://doi.org/10.1016/j.strueco.2021.03.011

Benli, M., & Acar, Y. (2022). Foreign direct investment and pollution in middle-income and OECD member countries. *Balkan Sosyal Bilimler Dergisi*, 11(21), 54-62.

Benzerrouk, Z., Abid, M., & Sekrafi, H. (2021). Pollution haven or halo effect? A comparative analysis of developing and developed countries. *Energy Reports*, 7, 4862-4871.

Bergougui, B., & Murshed, S. M. (2023). Spillover effects of FDI inflows on output growth: An analysis of aggregate and disaggregated FDI inflows of 13 MENA economies. *Australian Economic Papers*, 1–25. https://doi.org/10.1111/1467-8454.12320

Beton Kalmaz, D., & Awosusi A. A. (2022). Investigation of the driving factors of ecological footprint in Malaysia. Investigation of the driving factors of ecological footprint in Malaysia. *Environmental Science and Pollution Research*, 37, 56814-56827. https://doi.org/10.1007/s11356-022-19797-5

Bilgili, F. Ozturk, I., Kocak, E., Kuskaya, S., & Cingoz, A. (2022). The nexus between access to electricity and CO_2 damage in Asian Countries: The evidence from quantile regression models. *Energy & Buildings*, 256. 111761. https://doi.org/10.1016/j.enbuild.2021.111761

Brzezinski, Z. (1998). *The Grand Chessboard: American Primacy And Its Geostrategic Imperatives***,** New York: Basic Books.

Bulut, U., Ucler, G., Yilmaz, H. A., & Basaran, D. N. (2022). Is there a trade-off between financing current account deficits and environmental deterioration in developing countries? An empirical investigation for the validity of the pollution haven hypothesis. *Environmental Science and Pollution Research*, 29, 56090-56097. https://doi.org/10.1007/s11356-022-19819-2

Caetano, R.V., Marques, A.C., Afonso, T.L., & Vieira, I. (2022). A sectoral analysis of the role of foreign direct investment in pollution and energy transition in OECD countries. *Journal of Environmental Management*, 302.114018 https://doi.org/10.1016/j.jenvman.2021.114018

Cao, H., Khan, M.K., & Rehman, A. (2022). Impact of globalization, institutional quality, economic growth, electricity and renewable energy consumption on Carbon Dioxide Emission in OECD countries. *Environmental Science and Pollution Research*, 29, 24191-24202. https://doi.org/10.1007/s11356-021-17076-3

Chaudhry, I.S., Yin, W., Ali, S. A., Faheem, M., Abbas, Q., Farooq, F., & Rahman, S.U. (2022). Moderating role of institutional quality in validation of pollution haven hypothesis in BRICS: A new evidence by using DCCE approach. *Environmental Science and Pollution Research*, 29, 9193-9202. https://doi.org/10.1007/s11356-021-16087-4

Chen, F., Wang, L., Gu, Q., Wang, M., & Ding, X. (2022). Nexus between natural resources, financial development, green innovation and environmental sustainability in China: Fresh insight from novel quantile ARDL. *Resources Policy, 79,*102955. https://doi.org/10.1016/j. resou rpol. 2022. 102955

Chen, T., Bao, A., Jiapaer, G., Guo, Hao., Zheng, G., Jiang, L., Chang, C., & Tuerhanjiang, L. (2019). Disentangling the relative impacts of climate change and human activities on arid and semiarid grasslands in Central Asia during 1982–2015. *Science of the Total Environment,* 653, 1311-1325. https://doi.org/10.1016/j.scitotenv.2018.11.058

Cheng, C., Xiaohang, R., Kangyin, D., Xiucheng, D., & Zhen, W. (2021). How does technological innovation mitigate CO_2 emissions in OECD countries? Heterogeneous analysis using panel quantile regression. *Journal of Environmental Management*, 280, 111818. https://doi.org/10.1016/j.jenvman.2020.111818

Cheng, Y., & Yao, X. (2021). Carbon intensity reduction assessment of renewable energy technology innovation in China: A panel data model with cross-section dependence and slope heterogeneity. *Renewable and Sustainable Energy Reviews*, 135, 110157. https://doi.org/10.1016/j.rser.2020.110157

Churchill, S.A., Inekwe, J., Ivanovski, K., & Smyth, R. (2021). Transport infrastructure and CO_2 emissions in the OECD over the long run. *Transportation Research Part D: Transport and Environment*, 95, 102857. https://doi.org/10.1016/j.trd.2021.102857

Cil, N. (2022). Re-examination of pollution haven hypothesis for Turkey with Fourier approach. *Environmental Science and Pollution Research*, 30, 10024-10036. https://doi.org/10.1007/s11356-022-22800-8

Çakar, D, N., Gedikli, A., Erdoğan, S., & Yıldırım, D. Ç. (2021). A comparative analysis of the relationship between innovation and transport sector carbon emissions in developed and developing Mediterranean countries. *Environmental Science and Pollution Research*, 28, 45693-45713. https://doi.org/10.1007/s11356-021-13390-y

Dechezlepretre, A., Nachtigall, D., & Venmans, F. (2023). The joint impact of the European Union emissions trading system on carbon emissions and economic performance. *Journal of Environmental Economics and Management*, 118, 1-41. https://doi.org/10.1016/j.jeem.2022.102758

Dedeoğlu, M., Koçak, E., & Uucak, Z.Ş. (2021). The impact of immigration on human capital and carbon dioxide emissions in the USA: An empirical investigation. *Air Quality, Atmosphere & Health*, 14, 705-714. https://doi.org/10.1007/s11869-020-00973-w

Delisi, Matt., Beaver, K. M., Wright, K. A., Wright, J. P., Vaughn, M.G., & Trulson, C.R. (2011). Criminal specialization revisited: A simultaneous quantile regression approach. *American Journal of Criminal Justice*, 36, 73-92. https://doi.org/10.1007/s12103-010-9083-1

Dinh, T. T-H., Vo, D.H., Vo, A. T., & Nguyen T. C. (2019). Foreign Direct Investment and Economic Growth in the Short Run and Long Run: Empirical Evidence from Developing Countries. *Journal of Risk and Financial Management*, 12(4),1-11. https://doi.org/10.3390/jrfm12040176

Djellouli, N., Abdelli, L., Elheddad, M., Ahmed, R.., & Mahmood, H. (2022). The effects of non-renewable energy, renewable energy, economic growth, and foreign direct investment on the sustainability of African countries. *Renewable Energy*, 183, 676-686. https://doi.org/10.1016/j.renene.2021.10.066

Do, D.A., Song, Y., Do, H.T., Tran, T.T.H., & Nguyen, T.T. (2022). The effect of foreign direct investment inflow on exports: Evidence from Vietnam. *Journal of Asian Finance, Economics and Business*, 9(2), 0325-0333. https://doi.org/10.13106/jafeb.2022.vol9.no2.0325

Doğan, B., Driha, O.M., Balsalobre-Lorente, D., & Shahzad, U. (2020). The mitigating effects of economic complexity and renewable energy on carbon emissions in developed countries. *Sustainable Development*, 29, 1–12. https://doi.org/10.1002/sd.2125

D'Orazio, P., & Dirks, M.W. (2022). Exploring the effects of climate-related financial policies on carbon emissions in G20 countries: a panel quantile regression approach. *Environmental Science and Pollution Research*, 29, 7678–7702. https://doi.org/10.1007/s11356-021-15655-y

Dong, F., Li, Y., Gao, Y., Zhu, J., Qin, C., & Zhang, X. (2022). Energy transition and carbon neutrality: Exploring the non-linear impact of renewable energy development on carbon emission efficiency in developed countries. *Resources, Conservation and Recycling*, 177, 106002. https://doi.org/10.1016/j.resconrec.2021.106002

Du, L., Jiang, H., Adebayo, T.S., Awosusi, A.A., & Razzaq, A. (2022). Asymmetric effects of high-tech industry and renewable energy on consumption-based carbon emissions in MINT countries. *Renewable Energy*, 196, 1269-1280. https://doi.org/10.1016/j.renene.2022.07.028

Duan, Y., & Jiang, X. (2021). Pollution haven or pollution halo? A Re-evaluation on the role of multinational enterprises in global CO_2 emissions. *Energy Economics*, 97, 105181. https://doi.org/10.1016/j.eneco.2021.105181

Dwivedi, A. K., & Soni, A. (2022). Drivers and critical paths of carbon emissions in India: A structural path decomposition analysis. *Energy Sources, Part B: Economics, Planning, and Policy*, 17(1). https://doi.org/10.1080/15567249.2022.2084185

Dzator, J., Acheampong, A.O., & Dzator, M., (2021). The impact of transport infrastructure development on carbon emissions in OECD countries. *Environmental Sustainability and Economy*, 3–17. https://doi.org/10.1016/B978-0-12-822188-4.00006-3

Ercan, U. (2021). Türkiye hanehalkı sağlık harcamaları belirleyicilerinin kantil regresyon yöntemiyle incelenmesi. *Bingöl Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi*, 5(1), 141-172. https://doi.org/10.33399/biibfad.835976

Erdogan, S. (2021). Dynamic nexus between technological innovation and building sector carbon emissions in the BRICS countries. *Journal of Environmental Management*, 293, 112780. https://doi.org/10.1016/j.jenvman.2021.112780

Esen, O., Yıldırım, D. Ç., & Yıldırım, S. (2021). Pollute less or tax more? Asymmetries in the EU environmental taxes – Ecological balance nexus. *Environmental Impact Assessment Review*, 91, 106662. https://doi.org/10.1016/j.eiar.2021.106662

Eurostat, (2020). Greenhouse gas emission statistics - emission inventories. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Greenhouse_gas_emission_statistics_-_emission_inventories (Accessed: 20.06.2022).

Fang, K., Li, C., Tang, Y., He, J., & Song, J. (2022). China's pathways to peak carbon emissions: New insights from various industrial sectors. *Applied Energy*, 306, 118039. https://doi.org/10.1016/j.apenergy.2021.118039

Firoj, M., Sultana, N., Khanom, S., Rashid, M.H.U., & Sultana, A. (2023). Pollution haven hypothesis and the environmental Kuznets curve of Bangladesh: an empirical investigation. *Asia-Pacific Journal of Regional Science*, 7, 197-227. https://doi.org/10.1007/s41685-022-00258-3

Gao, L., Pei, T., Zhang, J., & Tian, Y. (2022). The "pollution halo" effect of FDI: Evidence from the Chinese Sichuan–Chongqing urban agglomeration. *International Journal of Environmental Research and Public Health*, 19, 11903. https://doi.org/10.3390/ijerph191911903

Gengenbach, C., Palm, F.C., & Urbain, J.-P. (2009). Panel unit root tests in the presence of cross-sectional dependencies: Comparison and implications for modeling. *Econometric Reviews*, 29(2) 111-145. https://doi.org/10.1080/07474930903382125

Godil, D., Sharif, A., Afshan, S., Yousuf, A., & Khan, S. (2020). The asymmetric role of Freight and Passenger Transportation in testing EKC in the US Economy: Evidence from QARDL approach. *Environmental Science and Pollution Research*, 27, 1-22. https://doi.org/10.1007/s11356-020-09299-7.

Gyamfi, B. A.. Bein, M. A.. Udemba, E.N., & Bekun, F. V. (2022). Renewable energy, economic globalization and foreign direct investment linkage for sustainable development in the E7 economies: revisiting the pollution haven hypothesis. *International Social Science*, 72, 91-110. https://doi.org/10.1111/issj.12301

Habiba, U., Xinbang, C., & Ahmad, R.I. (2021). The influence of stock market and financial institution development on carbon emissions with the importance of renewable energy consumption and foreign direct investment in G20 countries. *Environmental Science and Pollution Research*, 28, 67677–67688. https://doi.org/10.1007/s11356-021-15321-3

Handoyo, R.D., Rahmawati, Y., Altamirano, O.G.R., Ahsani, S.F., Hudang A.K., & Haryanto, T. (2022). An empirical investigation between FDI, tourism, and trade on CO_2 emission in Asia: Testing environmental kuznet curve and pollution haven hypothesis. *International Journal of Energy Economics and Policy*, 12(4), 385-393.

Heinold A. (2020). Comparing emission estimation models for rail freight transportation. *Transportation Research Part D: Transport and Environment*, 86, 102468. https://doi.org/10.1016/j.trd.2020.102468

Huang, W., Ortiz, G.G.R., Kuo, Y-L., Maneengam, A., Nassani, A. A., & Haffar, M. (2022a). The non-linear impact of renewable energy and trade on Consumption-based carbon emissions. *Fuel*, 324, 124423. https://doi.org/10.1016/j.fuel.2022.124423

Huang, Y., Kuldasheva, Z., & Bobojanov, S. (2022b). Exploring the links between fossil fuel energy consumption, industrial value-added, and carbon emissions in G20 countries. *Environmental Science and Pollution Research*, 30, 10854-10866. https://doi.org/10.1007/s11356-022-22605-9

Hussain, M., Bashir, M.F., & Shahzad, U. (2021). Do foreign direct investments help to bolster economic growth? New insights from Asian and Middle East economies. *World Journal of Entrepreneurship, Management and Sustainable Development*, 17(1), 62-84. https://doi.org/10.1108/WJEMSD-10-2019-0085

Hussain, Z., Khan, M.K., & Xia, Z. (2022). Investigating the role of green transport, environmental taxes and expenditures in mitigating the transport CO_2 emissions. *Transportation Letters*, 15(5), 439-449. https://doi.org/10.1080/19427867.2022.2065592

International Energy Association (IEA) (2019a). Cement. Tracking Clean Energy Progress. URL: www.idea.org/crept/indus ty/cement/ (Accessed: 20.01.2023).

International Energy Association (IEA) (2019b). https://iea.blob.core.windows.net/assets/fb7dc9e4-d5ff-4a22-ac07-ef3ca73ac680/The_Future_of_Rail.pdf (Accessed: 22.09.22)

IPPC (2018). Global warming of 1.5C. https://www.ipcc.ch/site/assets/uploads/sites/2/2019/06/SR15_Full_Report_High_Res.pdf (Accessed: 20.06.2022).

Iqbal, A., Tang, X., & Rasool, S.F. (2022). Investigating the nexus between CO_2 emissions, renewable energy consumption, FDI, exports and economic growth: evidence from BRICS countries. *Environment, Development and Sustainability,* 25, 2234-2263. https://doi.org/10.1007/s10668-022-02128-6

ITF (2019). Efficiency in railway operations and infrastructure management, ITF Roundtable Reports, 177. OECD Publishing, Paris,

John, O. O. (2015). Robustness of quantile regression to outliers. *American Journal of Applied Mathematics and Statistics*, 3(2), 86-88. doi:10.12691/ajams-3-2-8.

John, O. O., & Nduka, E. C. (2009). Quantile regression analysis as a robust alternative to ordinary least squares. *Scientia Africana*, 8(2), 61-65.

Jia, R., Shao, S., & Yang, L. (2021). High-speed rail and CO_2 emissions in urban China: A spatial difference-in-differences approach. *Energy Economics*, 99, 105271. https://doi.org/10.1016/j.eneco.2021.105271

Jijian, Z., Twum, A.K., Agyemang, A.O., Edziah, B.K., & Ayamba, E.C. (2021). Empirical study on the impact of international trade and foreign direct investment on carbon emission for Belt and Road countries. *Energy Reports*, 7, 7591–7600. https://doi.org/10.1016/j.egyr.2021.09.122 2

Joo, B.A., Shawl, S., & Makina, D. (2022). The interaction between FDI, host country characteristics and economic growth? A new panel evidence from BRICS. *Journal of Economics and Development*, 24(3), 247-261. https://doi.org/10.1108/JED-03-2021-0035

Joof, F., & Isiksal, A.Z. (2021). Do human capital and export diversification decline or augment CO_2 emissions? Empirical evidence from the MINT countries. *Journal of Environmental Accounting and Management*, 9(2), 111-125. https://doi.org/10.5890/JEAM.2021.06.002

Khan, M. K., Zahid, R.M.A., Saleem, A., & Sági, J. (2021b). Board composition and social & environmental accountability: a dynamic model analysis of Chinese firms. *Sustainability*, 13, 10662. https://doi.org/10.3390/su131-910662

Khan, S.A.R., Ponce, P., & Yu, Z. (2021a). Technological innovation and environmental taxes toward a carbon-free economy: An empirical study in the context of COP-21. *Journal of Environmental Management*, 298, 113418.

Kirikkaleli, D., & Adebayo, T.S. (2021). Do public-private partnerships in energy and renewable energy consumption matter for consumption-based carbon dioxide emissions in India? *Environmental Science and Pollution Research,* 28, 30139-30152. https://doi.org/10.1007/s11356-021-12692-5

Kirikkaleli, D., Awosusi, A.A., & Adebayo, T.S. (2023). Enhancing environmental quality in Portugal: can CO2 intensity of GDP and renewable energy consumption be the solution?. *Environmental Science and Pollution Research,* 30, 53796–53806. https://doi.org/10.1007/s11356-023-26191-2

Kisswani, K.M. & Zaitouni, M. (2023). Does FDI affect environmental degradation? Examining pollution haven and pollution halo hypotheses using ARDL modeling. *Journal of the Asia Pacific Economy*, 28(4), 1406-1432. https://doi.org/10.1080/13547860.2021.1949086

Leal, P.H., & Marques, A.C. (2022). The evolution of the environmental Kuznets curve hypothesis assessment: A literature review under a critical analysis perspective. *Heliyon*, 11521. https://doi.org/10.1016/j.heliyon.2022.e11521

Li, J., & Luo, N. (2020). Has the opening of high-speed rail improved the level of urban air pollution? *China Economic Quarterly*, 19(04),1335-1354.

Li, X., Sohail, S., & Majeed, M.T. (2021). Green logistics, economic growth, and environmental quality: evidence from one belt and road initiative economies. *Environmental Science and Pollution Research*, 28, 30664-30674. https://doi.org/10.1007/s11356-021-12839-4

Lin, S., Luo, N., & Yang, J. (2019). Vehicle structure and eco-efficiency: based on the dynamic spatial Durbin model. *Economic Geography*, 39(12), 21-30. https://doi.org/10.15957/j.cnki.jjdl.2019.12.003

Lin, Y., Qin, Y., & Wu, J. (2021). Impact of high-speed rail on road traffic and greenhouse gas emissions. *Nature Climate Change*, 11, 952–957. https://doi.org/10.1038/s41558-021-

Liu, Y., Sadiq, F., Ali, W., & Kumail, T. (2022). Does tourism development, energy consumption, trade openness and economic growth matters for ecological footprint: Testing the Environmental Kuznets Curve and pollution haven hypothesis for Pakistan. *Energy*, 245, 123208 https://doi.org/10.1016/j.energy.2022.123208

Lu, J., Li, B., Li, H., & Al-Barakani, A. (2021). Expansion of city scale, traffic modes, traffic congestion, and air pollution. *Cities*, 108,102974. https://doi.org/10.1016/j.cities.2020.102974

Ma, Q., Murshed, M., & Khan, Z. (2021). The nexuses between energy investments, technological innovations, emission taxes, and carbon emissions in China. *Energy Policy*, 155, 112345. https://doi.org/10.1016/j.enpol.2021.112345

Mackinder, H. J. (1904). The Geographical Pivot of History. *The Geographical Journal,* 23(4), 421-437.

Maji, S. G., & Saha, R. (2021). Gender diversity and financial performance in an emerging economy: empirical evidences from India. *Management Research Review*, 44(12), 1660-1683. https://doi.org/10.1108/MRR-08-2020-0525

Milanez, A. (2020). Workforce Ageing and Labour Productivity Dynamics. *Economy*, 66(3), 1-13. https://doi.org/10.2478/ngoe-2020-0013

Mkombe, D., Tufa, A.H., Alene, A.D., Manda, J., Feleke, S., Abdoulaye, T., & Manyong, V. (2021). The effects of foreign direct investment on youth unemployment in the Southern African Development Community. *Development Southern Africa*, 38, 6, 863-878, https://doi.org/10.1080/0376835X.2020.1796598

Mu, D., Hanif, S., Alam, K. M., & Hanif, O. (2022). A correlative study of modern logistics industry in developing economy and carbon emission using ARDL: A case of Pakistan. *Mathematics*, 10, 629. https://doi.org/10.3390/math10040629

Mukit, M. M. H., Abdel-Razzaq, A. I., & Islam, M. S. (2020). Relationship between unemployment and macroeconomics aggregates: Evidence from Bangladesh. *Journal of Economics and Financial Analysis*, 4(2), 45-61. https://orcid.org/0000-0002-7956-484X

Musah, M., Mensah, I. A., Alfred, M., Mahmood, H., Murshed, M., Sasu, A. Y. O., Boateng, F., Nyeadi, J. D., & Coffi, C. P. K. (2022). Reinvestigating the pollution haven hypothesis: the Nexus between foreign direct investments and environmental quality in G 20 countries. *Environmental Science and Pollution Research*, 29, 31330-31347. https://doi.org/10.1007/s11356-021-17508-0

Mustapa, S., & Bekhet, H. A. (2015). Investigating factors affecting CO_2 emissions in Malaysian road transport sector. *International Journal of Energy Economics and Policy*, *5*(4), 1073-1083.

Nasir, M. A., Huynh, T. L. D., & Tram, H. T. X. (2019). Role of financial development, economic growth & foreign direct investment in driving climate change: A case of emerging ASEAN. *Journal of Environmental Management*, 242, 131-141. https://doi.org/10.1016/j.jenvman.2019.03.112

Neves, S. A., Marques, A. C., & Patrico, M. (2020). Determinants of CO_2 emissions in European Union countries: Does environmental regulation reduce environmental pollution? *Economic Analysis and Policy*, 68, 114-125. https://doi.org/10.1016/j.eap.2020.09.005

Nguyen, D. K., Huynh, T. L. D., & Nasir, M. A. (2021). Carbon emissions determinants and forecasting: Evidence from G6 countries. *Journal of Environmental Management*, 285, 111988. https://doi.org/10.1016/j.jenvman.2021.111988

Nguyen, V. B. (2021). The Difference in the FDI- CO_2 emissions relationship between developed and developing countries: Empirical evidence based on institutional perspective. *Hitotsubashi Journal of Economics,* 62, 124-140. https://doi.org/10.15057/hje.2021006

Ni, T. V., Yusof, Z. Md., Misiran, M., & Supadi, S.S. (2021). Assessing youth unemployment rate in Malaysia using multiple linear regression. *Journal of Mathematics and Computing Science*, 7(1), 23-34.

Opoku, E. E. O., & Aluko, O. A. (2021). Heterogeneous effects of industrialization on the environment: Evidence from panel quantile regression. *Structural Change and Economic Dynamics*, 59, 174–184. https://doi.org/10.1016/j.strueco.2021.08.015

Pan, X., Guo, S., Xu, H., Tian, M., Pan, X., & Chu, J. (2022). China's carbon intensity factor decomposition and carbon emission decoupling analysis. *Energy*, 239(5), 122175. https://doi.org/10.1016/j.energy.2021.122175

Pavel, J., Tepperova, J., & Arltova, M. (2021). Tax factors affecting FDI allocation in the EU post-socialist states. *Post-Communist Economies*, 33(6), 710-725, https://doi.org/10.1080/14631377.2020.1827198

Poberezhskaya, M., & Bychkova, A. (2022). Kazakhstan's climate change policy: Reflecting national strength, green economy aspirations and international agenda. *Post-Communist Economies*, 34(7), 894-915. https://doi.org/10.1080/14631377.2021.1943916

Polloni-Silva, E., Ferraz, D., Camioto, F., Rebelatto, D. A. N., & Moralles, H. F. (2021). Environmental kuznets curve and the pollution-halo/haven hypotheses: An investigation in Brazilian municipalities. *Sustainability*, 13, 4114. https://doi.org/10.3390/su13084114

Polloni-Silva, E., Roiz, G. A., Mariano, E. B., Moralles, H. F., & Rebelatto, D. A. N. (2022). The environmental cost of attracting FDI: An empirical investigation in Brazil. *Sustainability*, 2022, 14, 4490. https://doi.org/ 10.3390/su14084490

Ponce, P., & Khan, S. A. R. (2021). A causal link between renewable energy, energy efficiency, property rights, and CO_2 emissions in developed countries: A road map for environmental sustainability. *Environmental Science and Pollution Research*, 28, 37804-37817. https://doi.org/10.1007/s11356-021-12465-0

Qayyum, M., Yu, Y., Nizamani, M. M, Raza, S., Ali, M., & Li, S. (2022). Financial instability and CO2 emissions in India: evidence from ARDL bound testing approach. *Energy & Environment*, 34(4), 808-829. https:// doi.org/10.1177/0958305X211065019

Qudrat-Ullah, H. (2022). A review and analysis of renewable energy policies and CO_2 emissions of Pakistan. *Energy*, 238, 21849. https://doi.org/10.1016/j.energy.2021.121849

Radmehr, R., Henneberry, S. R., & Shayanmehr, S. (2021). Renewable energy consumption, CO_2 emissions, and economic growth nexus: A simultaneity spatial modeling analysis of EU countries. *Structural Change and Economic Dynamics*, 57, 13-27. https://doi.org/10.1016/j.strueco.2021.01.006

Rahman, M.M., Nepal, R., & Alam, K. (2021). Impacts of human capital, exports, economic growth and energy consumption on CO_2 emissions of a cross-sectionally dependent panel: Evidence from the newly industrialized countries (NICs). *Environmental Science and Policy*, 121, 24–36 https://doi.org/10.1016/j.envsci.2021.03.017

Raihan, A., & Tuspekova, A. (2022). Dynamic impacts of economic growth, renewable energy use, urbanization, industrialization, tourism, agriculture, and forests on carbon emissions in Turkey. *Carbon Research*, 1-20. https://doi.org/10.1007/s44246-022-00019-z

Raza, S. A., Shah, N., & Sharif, A. (2019). Time-frequency relationship between energy consumption, economic growth and environmental degradation in the United States: Evidence from transportation sector. *Energy*, 173, 706–720. https://doi.org/10.1016/j.energy.2019.01.077

Rezk, H., Amer, G., Fathi, N., & Sun, S. (2022). The impact of FDI on income inequality in Egypt. *Economic Change and Restructuring*, 55, 2011–2030 (2022). https://doi.org/10.1007/s10644-021-09375-z

Ritchie, H., Roser, M., & Rosado, P. (2020). CO_2 and Greenhouse Gas Emissions, https://ourworldindata.org/emissions-by-sector (Accessed: 15.11.2022)

Rodrigue, J-P., Comtois, C., & Slack, B. (2020). *The Geography of transport systems*, Fifth edition, Routledge, https://doi.org/10.4324/9781315618159

Salahodjaev, R., & Isaeva, A. (2022). Post-Soviet states and CO_2 emissions: the role of foreign direct investment. *Post-Communist Economies*, 34(7), 944-965. https://doi.org/10.1080/14631377.2021.1965360

Serfraz, A., Qamruzzaman, M., & Karim, S. (2023). Revisiting the nexus between economic policy uncertainty, financial development, and FDI inflows in Pakistan during Covid-19: Does clean energy matter? *International Journal of Energy Economics and Policy*, 13(4), 91–101. https://doi.org/10.32479/ijeep.14360

Seum, S., Ehrenberger, S., & Pregger, T. (2020). Extended emission factors for future automotive propulsion in Germany considering fleet composition, new technologies and emissions from energy supplies. *Atmospheric Environment*, 233, 117568. https://doi.org/10.1016/j.atmosenv.2020.117568

Shahbaz, M., Li, J., Dong, X., & Dong, K. (2022). How financial inclusion affects the collaborative reduction of pollutant and carbon emissions: The case of China. *Energy Economics*, 107, 105847. https://doi.org/10.1016/j.eneco.2022.105847

Shahbaz, M., Nasreen, S., Abbas, F., & Anis, O. (2015a). Does foreign direct investment impede environmental quality in high-middle-, and low-income countries? *Energy Economics*, 51, 275-287. https://doi.org/10.1016/j.eneco.2015.06.014

Shahbaz, M., Khraief, N., & Jemaa, M. M. B. (2015b). On the causal nexus of road transport CO_2 emissions and macroeconomic variables in Tunisia: evidence from combined cointegration tests. *Renewable and Sustainable. Energy Reviews*, 51, 89–100. https://doi.org/10.1016/j.rser.2015.06.014

Shi, K., Di, B., Zhang, K., Feng, C., & Svirchev, L. (2018). Detrended cross-correlation analysis of urban traffic congestion and NO2 concentrations in Chengdu. *Transportation Research Part D: Transport and Environment*, 61, 165-173. https://doi.org/10.1016/j.trd.2016.12.012

Sikder, M., Wang, C., Yao, X., Huai, X., Wu, L., KwameYeboah, F., Wood, J., Zhao. Y., & Dou, X. (2022). The integrated impact of GDP growth, industrialization, energy use, and urbanization on CO2 emissions in developing countries: Evidence from the panel ARDL approach. *Science of the Total Environment*, 837,155795. https://doi.org/10.1016/j.

Sohail, M. T., Ullah, S., Majeed, M. T. & Usman, A. (2021). Pakistan management of green transportation and environmental pollution: A nonlinear ARDL analysis. *Environmental Science and Pollution Research,* 28, 29046–29055. https://doi.org/10.1007/s11356-021-12654-x

Song, W., Mao, H., & Han, X. (2021). The two-sided effects of foreign direct investment on carbon emissions performance in China. *Science of the Total Environment*, 791, 148331. https://doi.org/10.1016/j.scitotenv.2021.148331

Strauss, J., Li, H., & Cui, J. (2021). High-speed Rail's impact on airline demand and air carbon emissions in China. *Transport Policy*, 109, 85–97. https://doi.org/10.1016/j.tranpol.2021.05.019

Sun, L., & Li, W. (2021). Has the opening of high-speed rail reduced urban carbon emissions? Empirical analysis based on panel data of cities in China. *Journal of Cleaner Production*, 321, 128958. https://doi.org/10.1016/j.jclepro.2021.128958

Sun, Y., Yesilada, F., Andlib, Z., & Ajaz, T. (2021). The role of eco-innovation and globalization towards carbon neutrality in the USA. *Journal of Environmental Management*, 299, 113568. https://doi.org/10.1016/j.jenvman.2021.113568

Tang, Z., Mei, Z., & Zou, J. (2021). Does the opening of high-speed railway lines reduce the carbon ıntensity of China's resource-based cities? *Energies*, 14, 4648. https://doi.org/10.3390/en14154648

Tayebi, Z., Önel, G., & Moss, C. B. (2021). Use of panel time-series data with cross-section dependence in evaluating farmland valuation: A cautionary note. *Applied Economics Letters*, 28(6), 487-492, https://doi.org/10.1080/13504851.2020.1761527

Tayyar, A. E. (2022). Testing pollution haven and pollution halo hypotheses for the energy sector: Evidence from Turkey. *Business and Economics Research Journal*, 13(3), 367-383. http://dx.doi.org/10.20409/berj.2022.378

Tufail, M., Song, L., & Adebayo, T. S. (2021). Do fiscal decentralization and natural resources rent curb carbon emissions? Evidence from developed countries. *Environmental Science and Pollution Research,* 28, 49179-49190. https://doi.org/10.1007/s11356-021-13865-y

Usman, M., Balsalobre-Lorente, D., Jahanger, A., & Ahmad, P. (2022). Pollution concern during globalization mode in financially resource-rich countries: Do financial development, natural resources, and renewable energy consumption matter? *Renewable Energy*, 183, 90-102 https://doi.org/10.1016/j.renene.2021.10.067

Vujanović, N., Radošević, S., Stojčić, N., Hisarciklilar, Mehtap., & Iraj, H. (2022) FDI spillover effects on innovation activities of knowledge using and knowledge creating firms: Evidence from an emerging economy. *Technovation*, 118, 102512. https://doi.org/10.1016/j.technovation.2022.102512.

Wang, B., Sun, Y., Chen, Q., & Wang, Z. (2018). Determinants analysis of carbon dioxide emissions in passenger and freight transportation sectors in China. *Structural Change and Economic Dynamics,* 47,127–132. https://doi.org/10.1016/j.strueco.2018.08.003

Wang, H., & Luo, Q. (2022). Can a colonial legacy explain the pollution haven hypothesis? A city-level panel analysis, *Structural Change and Economic Dynamics*, 60, 482–495 https://doi.org/10.1016/j.strueco.2022.01.004

Wang, Q., Li, S., Li, R., & Jiang, F. (2022). Underestimated impact of the COVID-19 on carbon emission reduction in developing countries – A novel assessment based on scenario analysis. *Environmental Research*, 204, 111990. https://doi.org/10.1016/j.envres.2021.111990

World Economic Forum (WEF). (2022). The Global Risks Report 2022. Geneva: WEF- The Global Risks Report 2022. 17th Edition.

World Bank (2014). Eurasia's Development: Diversifying Economies, Naturally. https://www.worldbank.org/en/news/feature/2014/02/03/eurasias-development-investing-in-diversity-naturally (Accessed: 15.10.2022).

Wu, L., Sun, L., Qi, P., Ren, X., & Su, X. (2021). Energy endowment, industrial structure upgrading, and CO_2 emissions in China: Revisiting resource curse in the context of carbon emissions. *Resources Policy*, 74, 102329. https://doi.org/10.1016/j.resourpol.2021.102329

Wu, S., & Zhang, K. (2021). Influence of Urbanization and Foreign Direct Investment on Carbon Emission Efficiency: Evidence from Urban Clusters in the Yangtze River Economic Belt. *Sustainability*, 13, 2722. https://doi.org/10.3390/su13052722

Xenarios, S., Gafurov, A., & Schmidt-Vogt, D. (2019). Climate change and adaptation of mountain societies in Central Asia: uncertainties, knowledge gaps, and data constraints. *Regional Environmental Change*, 19, 1339–1352. https://doi.org/10.1007/s10113-018-1384-9

Xiangyu, S., Jammazi, R., & Aloui, C. (2021). On the nonlinear effects of energy consumption, economic growth, and tourism on carbon footprints in the USA. *Environmental Science and Pollution Research,* 28, 20128–20139. https://doi.org/10.1007/s11356-020-12242-5

Xie, Q., Adebayo, T. S., Irfan, M., & Altuntaş, M. (2022) Race to environmental sustainability: Can renewable energy consumption and technological innovation sustain the strides for China? *Renewable Energy*, 197. 320–330. https://doi.org/10.1016/j.renene.2022.07.138

Xu, C., Zhao, W., Zhang, M., & Cheng, B. (2021a). Pollution haven or halo? The role of the energy transition in the impact of FDI on SO2 emissions. *Science of the Total Environment*, 763, 143002 https://doi.org/10.1016/j.scitotenv.2020.143002

Xu, L., Fan, M., Yang, L., & Shao, S. (2021b). Heterogeneous green innovations and carbon emission performance: Evidence at China's city level. *Energy Economics*, 99, 105269. https://doi.org/10.1016/j.eneco.2021.105269

Yamaka, W., Phadkantha, R., & Rakpho, P. (2021). Economic and energy impacts on greenhouse gas emissions: A case study of China and the USA. *Energy Reports*, 7(3), 240-247. https://doi.org/10.1016/j.egyr.2021.06.040

Yang, B., Ali, M., & Hashmi, S. H. (2022). Do income inequality and institutional quality affect CO_2 emissions in developing economies? *Environmental Science and Pollution Research*, 29, 42720–42741. https://doi.org/10.1007/s11356-021-18278-5

Yang, X., Li, Nan., Mu, H., Pang, J., Zhao, H., & Ahmad, M. (2021a). Study on the long-term impact of economic globalization and population aging on CO_2 emissions in OECD countries. *Science of The Total Environment,* 787, 147625 https://doi.org/10.1016/j.scitotenv.2021.147625

Yang, H., Shahzadi, I., & Hussain, M. (2021b). USA carbon neutrality target: Evaluating the role of environmentally adjusted multifactor productivity growth in limiting carbon emissions. *Journal of Environmental Management*, 298, 113385 https://doi.org/10.1016/j.jenvman.2021.113385

Yıldırım, A. E., & Yıldırım, M. O. (2021). Revisiting the determinants of carbon emissions for Turkey: the role of construction sector. *Environmental Science and Pollution Research*, 28, 42325-42338. https://doi.org/10.1007/s11356-021-13722-y

Yousaf, H., Amin, A., & Baloch, A. (2021). Investigating household sector's non-renewables, biomass energy consumption and carbon emissions for Pakistan. *Environmental Science and Pollution Research*, 28, 40824-40834. https://doi.org/10.1007/s11356-021-12990-y

Yu, Y., & Zhang, N. (2021). Low-carbon city pilot and carbon emission efficiency: Quasi-experimental evidence from China. *Energy Economics*, 96, 105125. https://doi.org/10.1016/j.eneco.2021.105125

Yu, Z., Khan, S. A. R., Ponce, P., de Sousa Jabbour, A. B. L., & Jabbour, C. J. C. (2022). Factors affecting carbon emissions in emerging economies in the context of a green recovery: Implications for sustainable development goals. *Technological Forecasting and Social Change*, 176, 121417. https://doi.org/10. 1016/j. techf ore. 2021. 121417

Zafar, M. W., Sinha, A., Ahmed, Z., Qin, Q., & Zaidi, S. A. H. (2021). Effects of biomass energy consumption on environmental quality: The role of education and technology in Asia-Pacific Economic Cooperation countries. *Renewable and Sustainable Energy Reviews*, 142, 110868 https://doi.org/10.1016/j.rser.2021.110868

Zaidi, S. A. H., Hussain, M., & Zaman, Q. U. (2021). Dynamic linkages between financial inclusion and carbon emissions: Evidence from selected OECD countries. *Resources, Environment and Sustainability*, 4, 100022, https://doi.org/10.1016/j.resenv.2021.100022

Zhang, W., Huang, Y., & Wu, H. (2022). The symmetric and asymmetric effects of economic policy uncertainty and oil prices on carbon emissions in the USA and China: evidence from the ARDL and non-linear ARDL approaches. *Environmental Science and Pollution Research*, 29, 26465–26482. https://doi.org/10.1007/s11356-021-17839-y

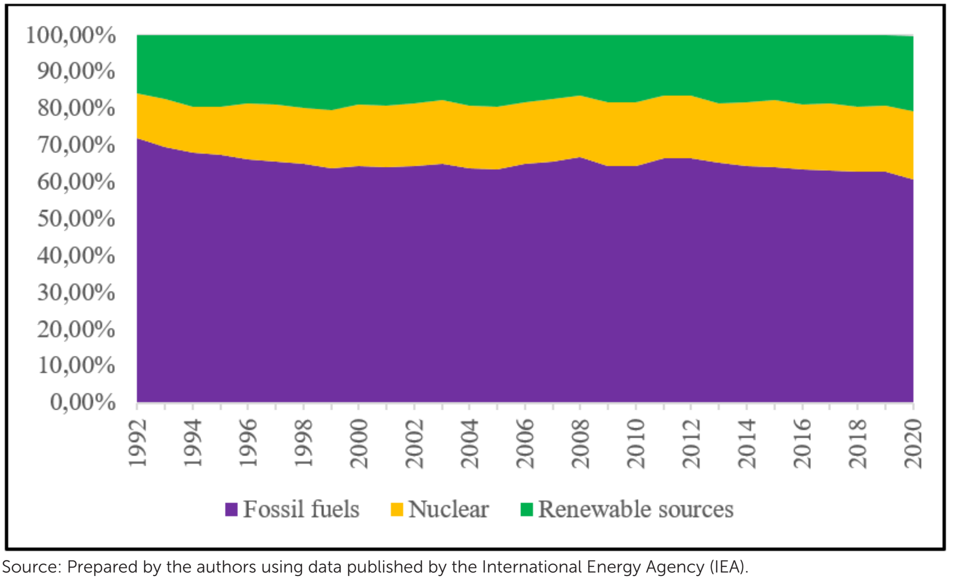
Zhao, C., Wang, K., Dong, X., & Dong, K. (2022). Is smart transportation associated with reduced carbon emissions? The case of China. *Energy Economics*, 105, 105715. https://doi.org/10.1016/j.eneco.2021.105715

Zhou, Y., Xu, X., & Tao, L. (2022). The impact mechanism of high-speed railway on regional green innovation spillover under multi-dimensional paths. *Environmental Impact Assessment Review,* 95, 106795. https://doi.org/10.1016/j.eiar.2022.106795

Zhu, X., Jianguo, D., & Ali, K. (20203). Do green logistics and green finance matter for achieving the carbon neutrality goal?. *Environmental Science and Pollution Research,* 30, 115571-115584. https://doi.org/10.1007/s11356-023-30434-7

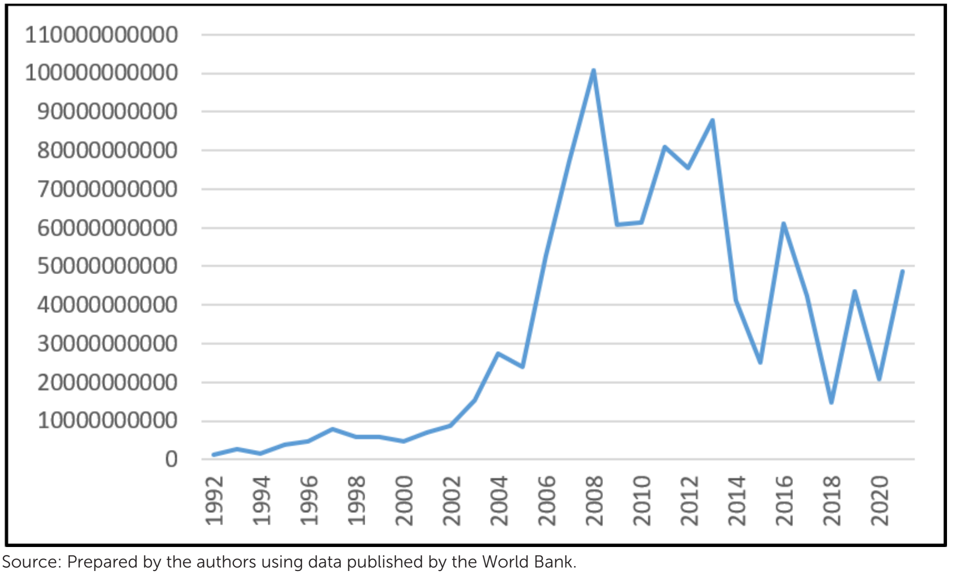
APPENDIX

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.