Fiscaoeconomia
E-ISSN: 2564-7504
2024, Volume 8, Issue 3, 1617-1640
https://dergipark.org.tr/tr/pub/fsecon

Submitted/Geliş: 09.07.2024
Accepted/Kabul: 22.08.2024
Doi: 10.25295/fsecon.1513450

Research Article/Araştırma Makalesi

Finansal Gelişme, Doğrudan Yabancı Yatırımlar ve Jeopolitik Riskin CO_2 Emisyonları Üzerindeki Etkisi: Türkiye'den Kanıtlar

The Impact of Financial Development, Foreign Direct Investment and Geopolitical Risk on CO_2 Emissions: Evidence from Turkey

Şehmus AYDIN[1], Ferhat ÖZTUTUŞ[2], İbrahim Halil POLAT[3]

Abstract

The rise in greenhouse gas emissions, particularly carbon dioxide (CO_2), represents one of the most significant challenges facing humanity's existence in the 21st century. It is crucial to implement the measures to reduce these emissions to achieve environmental sustainability. Turkey, along with many nations, is striving to reduce its CO_2 emissions in accordance with the United Nations' 2030 Sustainable Development Goals. This study explores the effects of financial development (FIN), foreign direct investment (FDI), and geopolitical risk (GPR) on Turkey's CO_2 emissions, using annual data from 1985 to 2022. To investigate long-term relationships among these variables, we apply the RALS-Fourier ADF (RALS-FADF) unit root test, the Fractional Fourier ADL (FFADL) cointegration test, and the Fully Modified Ordinary Least Squares (FMOLS) method. The evidence from the FMOLS show that FIN, FDI, and GPR lead to higher CO_2 emissions in Turkey over time. It is concluded that any policies designed to achieve a sustainable environmental quality in Turkey must consider mitigating the negative effects of the financial development, foreign direct investment and geopolitical risks on the environment.

Jel Codes: *F18, Q56, P18*
Keywords: *CO_2 Emissions, Financial Development, Foreign Direct Investment, Geopolitical Risk, Turkey*

[1] Assist. Prof. Dr., Hakkâri University, Department of Business, sehmusaydin@hakkari.edu.tr, ORCID: 0000-0001-5040-6517
[2] Assist. Prof. Dr., Hakkâri University, Department of Economics, ferhatoztutus@hakkari.edu.tr, ORCID: 0000-0001-6146-144X
[3] Assist. Prof. Dr., Hakkâri University, Department of Economics, ibrahimhalilpolat@hakkari.edu.tr, ORCID: 0000-0001-9785-160X

Citation/Atıf: Aydın, Ş., Öztutuş, F. & Polat, İ. H. (2024). The Impact of Financial Development, Foreign Direct Investment and Geopolitical Risk on CO2 Emissions: Evidence from Turkey. *Fiscaoeconomia, 8*(3), 1617-1640. Doi: 10.25295/fsecon.1513450

Aydın, Ş., Öztutuş, F. & Polat, İ. H. (2024). The Impact of Financial Development, Foreign Direct Investment and Geopolitical Risk on CO2 Emissions: Evidence from Turkey. *Fiscaoeconomia, 8*(3), 1617-1640. Doi: 10.25295/fsecon.1513450

Öz

Başta karbondioksit (CO_2) olmak üzere sera gazları emisyonlarındaki artış, 21. yüzyılda insanlığın karşı karşıya olduğu en önemli zorluklardan birini teşkil etmektedir. Çevresel sürdürülebilirliğin sağlanması için bu emisyonların azaltılmasına yönelik tedbirlerin uygulanması büyük önem taşımaktadır. Türkiye, birçok ülke ile birlikte, Birleşmiş Milletler'in 2030 Sürdürülebilir Kalkınma Hedefleri doğrultusunda CO_2 emisyonlarını azaltmaya çalışmaktadır. Bu bağlamda bu çalışma, 1985-2022 yılları arasındaki yıllık verileri kullanarak, finansal gelişme (FIN), doğrudan yabancı yatırımlar (FDI) ve jeopolitik riskin (GPR) Türkiye'deki CO_2 emisyonları üzerindeki etkilerini araştırmaktadır. Değişkenler arasındaki uzun vadeli ilişkileri ortaya koymak için RALS-Fourier ADF (RALS-FADF) birim kök testi, Kesirli Fourier ADL (FFADL) eşbütünleşme testi ve Tam Düzeltilmiş Sıradan En Küçük Kareler (FMOLS) yöntemleri kullanılmıştır. FMOLS metodundan elde edilen araştırma bulguları, FIN, FDI ve GPR'nin Türkiye'de uzun dönemde CO2 emisyonunu arttırdığını göstermektedir. Dolayısıyla, Türkiye'de sürdürülebilir bir çevre kalitesine ulaşabilmek için, finansal kalkınma, doğrudan yabancı yatırımlar ve jeopolitik risklerle ilgili olarak tasarlanacak politikaların çevre üzerindeki olumsuz etkilerini en aza indirecek şekilde tasarlanması gerekmektedir.

Jel Kodları: *F18, Q56, P18*
Anahtar Kelimeler: *CO_2 Emisyonları, Finansal Kalkınma, Doğrudan Yabancı Yatırım, Jeopolitik Risk, Türkiye*

1. Introduction

The issue of global warming has been a significant focus for environmentalists, economists, policymakers, and academics alike. This is due to the fact that environmental degradation and global climate change have the potential to impede or be likely affected by economic growth and sustainable development practices in both developed and developing economies. Academic studies have identified the rapid increase in greenhouse gases, particularly CO_2 emissions, as the primary cause of the environmental challenges or climate change. It has been revealed that the share of CO_2 emissions in total greenhouse gases corresponds to approximately 76% (Anser *et al.*, 2021; Coşkuner *et al.*, 2020). This problem does not only impact the environment but also directly affects the economy, social life, lifestyle, geopolitical factors, and politics (Hao & Liu, 2015; Koçak & Şarkgüneşi, 2018). Regulating CO_2 emissions is essential to ensure a sustainable environment that can support continued economic and social development. However, prior to implementing measures to regulate CO_2 emissions, it is of utmost importance to investigate the factors that contribute to CO_2 emissions. Researchers have identified a number of social, economic and political factors that are related to CO_2 emissions (Anser *et al.*, 2021; Caruso *et al.*, 2020; Ding *et al.*, 2021; Li *et al.*, 2021; Saadaoui *et al.*, 2024; Zhao *et al.*, 2023) such as geopolitical risk, foreign direct investment (inflows) and financial development.

Geopolitical risk (GPR) is a global phenomenon that affects nearly every region of the globe. The economic and social impacts of GPR are well documented in the literature. GPR can result in a reduction in CO_2 emissions, either through a reduction in economic growth and energy consumption or by promoting the use of renewable energy resources (Anser *et al.*, 2021; İmamoğlu, 2023; Ma *et al.*, 2022). Conversely, GPR may result in an increase in CO_2 emissions due to the inhibition of innovation, research and development (R&D), and renewable energy consumption, or by encouraging production methods utilising fossil fuels that are associated with high CO_2 emissions (Anser *et al.*, 2021). Therefore, it is imperative to conduct country-specific research on the correlation between CO_2 emissions and GPR in order to elucidate this complexity.

Moreover, the majority of research on the relationship between financial development and carbon dioxide (CO_2) emissions has demonstrated that financial development is a pivotal factor influencing the extent of CO_2 emissions (Lv & Li, 2021; Habiba & Xinbang, 2022). Within this structure, two primary divergent perspectives are present in the literature explaining how financial development affects CO_2 emissions. The first perspective posits that financial development has a positive effect on CO_2 emissions (Tamazian *et al.*, 2009; Khan *et al.*, 2014; Saud *et al.*, 2019; Shahbaz *et al.*, 2016; Zhang, 2011), while the second asserts that financial development is detrimental to CO_2 emissions (Ahmad *et al.*, 2018; Amri, 2018; Anwar *et al.*, 2022; Atsu *et al.*, 2021; Boutabba, 2014; Farhani & Ozturk, 2015; Gill *et al.*, 2019; Lu, 2018; Mahalik & Mallick, 2014; Park *et al.*, 2018; Shahbaz *et al.*, 2016; Xu *et al.*, 2018; Zhang, 2011). Moreover, a few studies in the literature have found a non-significant relationship between financial development and CO_2 emissions (Omri *et al.*, 2015; Salahuddin *et al.*, 2018; Assi *et al.*, 2021). The contradictions, different opinions, and lack of consensus in the literature lead researchers to believe that it would be more accurate to examine the relationship between financial development and CO_2 emissions on a country-by-country basis.

A further motivating factor for this study is foreign direct investment (inflows). foreign direct investment can provide significant advantages for a country seeking to increase capital accumulation, market access, international competitiveness, economies of scale, economic growth, technology transfer, and employment. For example, foreign direct investment inflows to Turkey have reached a total of USD 176 billion between 2001 and 2023 (UNCTAD, 2024). However, foreign direct investment can also bring with it significant disadvantages. These include increasing CO_2 emissions, environmental degradation and health issues due to growing business activities (Essandoh *et al.*, 2020). Despite the positive contribution of foreign direct investment to economic growth and development, there has been a substantial debate among national and international circles regarding the potential negative impacts of foreign direct investment on environmental quality.

Furthermore, Turkey's gross domestic product (GDP) has increased from around USD 150 billion in 1990 to around USD 795 billion in 2023 (World Bank, 2024). Turkey's transition to a free market economy in the 1990s has also been accompanied by a notable increase in consumption and investment credit provided by the financial sector during this period. It is well established in the literature that financial development is a key factor in achieving this high GDP growth (Saadaoui *et al.*, 2024). However, the financial development associated with high growth is accompanied by a number of negative effects, including an increase in carbon dioxide (CO_2) emissions. Therefore, assessing the impact of financial development on carbon dioxide (CO_2) emissions in Turkey can help develop structural strategies to reduce CO_2 emissions and protect the environment, in line with the country's sustainable development goals.

Geopolitically, Turkey sits at the crossroads of Arab, Caucasian and Western cultures, acting as a bridge between Europe and Asia. From a geopolitical perspective, Turkey is a strategic region for a number of reasons. First, Turkey is close to the world's major energy sources and lies on a vital energy and supply chains corridor with land, sea and air links. Second, Turkey's energy consumption is higher than that of the emerging countries in the region. Third, it is on trade routes and has the ports needed for the logistics of raw materials such as oil and natural gas. Fourth, Turkey's strategic location means that it borders with the nations that have been engaged in protracted conflict for years, which has had a negative impact on the country's social, economic and environmental conditions. The selected time period selected for the analysis covers important GPR events in Turkey such as the coup d'état (1984), Iraq war (2003-2011), Syrian war (after 2013), the Gezi Park protests (2013), coup attempt (2016) and so on. According to some statistics, Turkey is the fifteenth largest emitter in the world with approximately 400 million tonnes of CO_2 emissions in 2023 (approximately 1.2% of the world's total CO_2 emissions) (Byrne *et al.*, 2023; IEA, 2024). In order to achieve a sustainable environment and protect human health, and as a member of the G-20, Turkey has set a net zero emissions target by 2053; therefore, Turkey needs to reduce these polluting emissions. Determining how these factors affect the environment in Turkey is crucial in this regard.

In light of the aforementioned justifications, the primary objective of this research is to examine the effect of foreign direct investment, geopolitical risk and financial development on CO_2 levels for the Turkish economy from 1985 to 2021. In order to accomplish this, the study utilizes the residual augmented least square-Fourier augmented unit root test (RALS-FADF), fractional Fourier ADL cointegration test (FFADL), and fully modified ordinary least squares (FMOLS). The study makes a significant contribution to the existing literature in several ways. It is the first paper to examine the impact of geopolitical risk (GPR), foreign direct investment inflows (FDI) and financial development (FIN) on Turkey's CO_2 emissions using an advanced econometric analysis method to reveal the nexus among between the variables.

The remainder of the study is as follows: a literature review on the relationship between FDI, FIN, GPR and CO_2 emissions is presented in the next section. The data set, variables, econometric model and methodology used in the study are presented in the following section. The empirical results are then presented. Finally, the paper concludes with recommendations for possible future policy implications.

2. Literature Review

Balıbey (2015) examines the relationship between CO_2, GDP and FDI for Turkey from 1974 to 2011 using Johansen cointegration and Granger causality methods. It is found that both FDI and GDP contribute significantly to CO_2 emissions. It is also shown that the relationship between FDI and CO_2 is bidirectional, while the relationship between GDP and CO_2 is unidirectional. Environmental pollution is significantly influenced by GDP in particular. The findings also support the validity of the Environmental Kuznets Curve (EKC) hypothesis in Turkey.

Şeker *et al.* (2015) utilizes the ARDL and Hatemi-J methods to analyse the effect of GDP, FDI and energy consumption on CO_2 in Turkey from 1974 to 2015. The results indicate that although FDI has a small but positive effect on CO_2, GDP and energy consumption have a significant and positive effect on CO_2. Additionally, the causality analysis results reveal a unidirectional causal relationship between FDI, energy consumption, GDP, and CO_2. The paper concludes that the EKC hypothesis is valid within the context of Turkey.

Abbasi & Riaz (2016) employs the Granger causality and ARDL tests to investigate the relationship between GDP, financial development and CO_2 for Pakistan from 1970 to 2011. The findings indicate that only GDP has a negative association with CO_2, while financial development and GDP exhibit a long-run positive cointegration relationship with CO_2. The results of the Granger causality test indicates that the relationship between financial development and CO_2 was exclusively unidirectional.

Koçak & Şarkgüneşi (2017) explores the relation between international trade, foreign direct investment and CO_2 emissions for 9 Black Sea and Balkan countries in total. The authors use panel data from 1990 to 2012 and utilise Pedroni's (1999, 2000, 2001, 2004) panel cointegration methods, along with Dumitrescu & Hurlin's (2012) techniques for heterogeneous panel causality estimation. The research's findings indicate that there is a sustainable link between the use of renewable energy and economic growth over the long term, which is evidenced by the positive contribution of renewable energy consumption to economic growth. The heterogeneous panel causality analysis further provides support for the growth hypothesis in Bulgaria, Greece, North Macedonia, Russia, and Ukraine; confirms the feedback hypothesis in Albania, Georgia, and Romania; and shows the neutrality hypothesis in Turkey.

Essandoh *et al.* (2020) investigated the relationship between trade openness, GDP, renewable energy consumption, non-renewable energy consumption, foreign direct investment (FDI), and CO_2 for 52 developed and developing country groups, using PMG-ARDL and the panel Granger causality model over the period 1991 and 2014. The results showed that, in developed countries, there is a long-term adverse relationship between CO_2 emissions and international trade. Conversely, FDI and CO_2 were found to have a positive long-term relationship in emerging nations. A unidirectional causality relationship was discovered between GDP and CO_2, non-renewable energy consumption and CO_2, GDP and non-renewable energy consumption, trade openness and non-renewable energy consumption, FDI and non-renewable energy consumption, and renewable energy consumption and GDP, as well as FDI and GDP, for the causality results. Conversely, a bidirectional relationship was shown between trade openness and FDI, renewable energy resources, non-renewable energy consumption, and CO_2 renewable energy consumption. The study's three key variables were FDI, trade openness, and CO_2, although no causal relationship was discovered between them.

Koçak and Şarkgüneşi (2017) explored how foreign direct investment (FDI) influences carbon dioxide (CO2) emissions in Turkey, focusing on data spanning from 1974 to 2013. They used the Environmental Kuznets Curve (EKC) model as a framework and employed several advanced statistical methods, including the Maki structural break cointegration test, Dynamic Ordinary Least Squares (DOLS), and the Hacker and Hatemi-J's bootstrap causality test, to analyse the data. Their research uncovered a significant long-term relationship between CO2 emissions, economic growth, energy consumption, and FDI. Interestingly, their results supported the Pollution Haven Hypothesis (PHH) for Turkey, suggesting that FDI contributes to increased CO2 emissions. Additionally, they found a reciprocal relationship: not only does FDI drive up emissions, but higher emissions levels also seem to attract more FDI to the country.

Alsagr & Hemmen (2021) study how financial development (FD) and geopolitical risk (GPR) affect renewable energy consumption (REC) in 19 emerging markets from 1996 to 2015. The authors use four measures of financial development (bank lending, loan-to-deposit ratio, bank credit to the private sector and stock market turnover ratio) and the GPR index developed by Caldara & Iacoviello (2018) as the main predictor variables. The research also takes into account foreign direct investment, consumer price index and GDP per capita. The analysis is performed using a two-stage GMM model. The results indicate that FD has a significant positive effect on REC, and this effect is more pronounced in the long run. Contrary to the expected negative effect, GPR has a significant positive impact on REC, which is attributed to the need for energy security and the substitution effect between renewable and non-renewable energy sources.

Anser *et al.* (2021) investigate how geopolitical risk (GPR) affects CO_2 emissions in the BRICS countries (Brazil, Russia, India, China and South Africa) using the AMG estimator and Westerlund's (2007) cointegration technique to analyse the long-term influence of GPR on CO_2 emissions. The data used spans the period from 1985 to 2015. The empirical findings present that the relationship between GPR and CO_2 emissions is positive and statistically significant, with a 1% increase in GPR leading to a 0.13% increase in CO_2 emissions in the BRICS countries. The non-renewable energy consumption (ENE) variable has a positive correlation with CO_2 emissions, indicating that a 1% increase in non-renewable energy consumption leads to a 0.21% increase in CO_2 emissions. The coefficient on the REN variable is negative and statistically significant, meaning that a 1% rise in renewable energy consumption reduces CO_2 emissions by 0.09%. The POP (population) and GDP (GDP per capita) variables are positively associated with CO_2 emissions, indicating that population growth and economic development contribute to higher emission levels.

In his study, Bildirici (2021) explores the relationship between terrorism, CO_2, foreign direct investment, energy consumption, and GDP for China, Israel, India, and Turkey for the period 1975-2017 using Pedroni, Kao, & Westerlund cointegration and Panel causality analysis, and Dumitrescu & Hurlin causality analysis. According to the results, a unidirectional causality relationship is found between GDP and CO_2, GDP and foreign direct investment, and energy consumption and CO_2 in these countries. It was also found that terrorism is the causality between CO_2 and energy consumption. In other words, it is emphasized that the more terrorism incidents occur, the more social, economic, environmental, and political events will increase in these countries.

Cengiz & Manga (2022) examine how geopolitical risk and climate change relate by analyzing annual panel data from 1990 to 2015 in 12 Latin American and Asian nations. The paper uses the Augmented Mean Group (AMG) method, a second-generation estimator, to examine the long-run relationship between geopolitical risk and per capita CO_2 emissions. The study focuses on CO_2 emissions per capita as the dependent variable, with the Geopolitical Risk Index (GPR), GDP per capita, total population (POP), fossil energy use (FUSE) and renewable energy use (REN) as independent variables. The results from AMG analysis shows that a 1% increase in geopolitical risk leads to a 0.001% increase in per capita CO_2 emissions. It also found that as the economy grows and more fossil fuels are used, per capita CO_2 emissions increase, while an increase in the use of renewable energy leads to a reduction in per capita CO_2 emissions.

Habiba & Xinbang (2022) examines the effect of financial development, GDP, non-renewable energy sources, renewable energy sources, trade openness, and urbanization on CO_2 for 22 developed and 24 developing countries from 2000 to 2018 using the GMM technique. According to the analysis results, financial development reduces CO_2 emissions in developed countries. On the other hand, it was found that financial development increases CO_2 in developing countries. In addition, consumption of renewable energy sources was found to reduce CO_2 in both country groups. GDP, trade openness, and non-renewable energy sources are significant contributors to environmental pollution.

In their study, Ma *et al.* (2022) examined how GPR, energy usage, FDI and GDP affected CO_2 levels in both developed and developing countries between 1990 and 2020. They used the PMG-ARDL model to test the co-integration and calculate the short- and long-term correlations between these factors. The variables consist of carbon dioxide emissions, gross domestic product (GDP) per capita, foreign direct investment (FDI), energy consumption and political risk. Based on the results of the analysis, the environmental Kuznets curve hypothesis does not hold for these countries. The GPR is found to significantly increase CO_2 emissions, while energy consumption and financial development increases CO_2 emissions in all countries.

Wang *et al.* (2022) uses the monthly data from 2000-2020 to estimate the nexus between China's geopolitical risk (GPR) and carbon dioxide (CO_2) emissions. It applies the Augmented Dickey-Fuller (ADF), Phillips-Perron (PP), and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) unit root tests to test the stationarity of the variables. The Granger causality test is used to investigate the causal relationship between GPR and CO_2. The results show that there is a reciprocal relationship between GPR and CO_2 emissions in China. The results further demonstrate that GPR affects both energy consumption and military operations, resulting in a multi-faceted impact on CO_2 emissions. In this regard, they found that the impact of GPR on CO_2 is both positive and negative depending on the dominance of these different mechanisms. The authors concluded that GPR affects CO_2 emissions in 3 ways: consumption, investment, and mitigation effects.

Saadaoui *et al.* (2024) studies the impact of financial development, geopolitical risk, hydroelectricity generation income, and foreign direct investment on carbon emissions in Turkey between 1985 and 2021. They employ the Autoregressive Distributed Lag (ARDL) model to analyse the time series data for carbon emissions, hydroelectric power generation, geopolitical risk, GDP per capita, financial development, and foreign direct investment. It has been demonstrated that the generation of hydropower has a long-term effect on reducing carbon emissions, with this effect being more significant than the short-term impact. In addition, geopolitical risk and financial development have been found to have a negative influence on carbon emissions in the long run, while income and foreign direct investment have a positive impact. The spectral causality analysis revealed bidirectional causality between hydroelectricity and carbon emissions at high frequencies, with unidirectional causality from hydroelectricity to carbon emissions at medium to low frequencies. Furthermore, the analysis demonstrated that financial development causes carbon emissions at high frequencies, whereas carbon emissions cause foreign direct investment at medium to low frequencies.

Ali *et al.* (2023) focuses on researching the influence of energy resources (renewable energy consumption (RENE), non-renewable energy consumption (NREC), and financial development (FND)) on environmental sustainability in the Emerging-7 economies (Brazil, China, India, Indonesia, Mexico, Russia, and Turkey) from 2000 to 2020. The paper employs a range of statistical tests to assess robustness, including the normality test, slope heterogeneity test, cross-section dependency test, the panel unit root test, cointegration test, the long-run estimation regression, and the panel quantile regression and cross-correlation estimation method for mean groups, respectively. Increased RENE resources positively impact environmental sustainability, while NREC resources and FND adversely affect CO_2 emissions in the E-7 economies. The is reported that the long-run analysis reveals that a 1% increase in RENE, NREC, and FND leads to a 0.51%, 0.48%, and 0.58% change in CO_2 emissions, respectively. The FND has a positive and significant impact on CO_2 emissions, suggesting that increased financial development may lead to higher environmental degradation in the Emerging-7 economies.

Lorente *et al.* (2023) focuses on the relationship between financial development, foreign direct investment, corruption, strict environmental regulations, trade openness, renewable energy sources and the ecological footprint by analysing time series data from 1994 to 2018 by Fisher causality analysis for Asia-Pacific Economic Cooperation (APEC) countries. The findings show a curvilinear relationship between FDI and ecological footprint. CO_2 emissions are reduced by following strict environmental regulations, increasing the use of renewable energy, fighting corruption and promoting financial growth. Conversely, an increase in FDI and trade openness increases the carbon footprint. This relationship confirms the hypothesis of pollution havens within these countries. Based on the causality analysis, there is a mutual causality between ecological footprint and financial development, as well as strong environmental policies, anti-corruption measures, renewable energy consumption, FDI and trade openness.

In their study, Uddin *et al.* (2023) investigate the influence of geopolitical risk, governance, technological innovations, energy use, and foreign direct investment on CO_2 emissions in the BRICS (Brazil, Russia, India, China, and South Africa) region from 1990 to 2018. The data set encompasses a diverse array of variables, including carbon emissions, the geopolitical risk index, corruption, political stability and the absence of violence/terrorism, government effectiveness, regulatory quality, the rule of law, energy consumption, foreign direct investment, and innovations for the BRICS countries. In order to address the issue of cross-sectional dependence, the CS-ARDL (cross-sectionally auto-regressive distributed lag) approach is employed. Furthermore, the FMOLS (fully modified ordinary least squares) and DOLS (dynamic ordinary least squares) methods are employed to provide long-run estimates. The results indicate an inverse relationship between CO_2 emissions and several factors, including government effectiveness, regulatory quality, the rule of law, levels of foreign direct investment (FDI), and innovation. In contrast, a direct correlation is identified between CO_2 emissions and geopolitical risk, corruption, and energy consumption.

Zhao *et al.* (2023) examined the effect of GPR, GDP, CO_2, natural gas, and globalization on renewable energy consumption for 20 OECD countries from 1970-2019 using the GMM method. The findings suggest that GPR has a negative impact on renewable energy consumption in these countries. In other words, GPR is found to pose a potential threat to climate change by negatively impacting the consumption of renewable energy resources. According to their findings, a 1% increase in GDP increases renewable energy demand by 0.09%. Finally, a 1% increase in CO_2 decreases renewable energy consumption by 0.35%.

Chen *et al.* (2024) investigated the effect of GPR, GDP, globalization, and labour capital on CO_2 for 38 developed and developing countries from 1990-2019 using the panel cointegration test and panel causality methods developed by Kao & Pedroni (1999). According to the results, a long-run cointegration relationship was found between all variables. In addition, GPR, labour capital, and GDP increase CO_2 emissions, whereas globalization has a negative effect on CO_2 emissions. According to the causality results, no causality relationship was found between GPR and CO_2.

As seen in the literature review, the effect of FIN, FDI and GPR on CO_2 emissions is significant. Therefore, we believe that an analysis of the relationship between these variables at the country level will be a valuable contribution to the existing literature.

3. Data and Research Method

We have used annual data from 1985 to 2022 to estimate the nexus between the financial development index (FIN), geopolitical risk (GPR), foreign direct investment (FDI), and CO_2 emissions per capita (CO_2PC), used as a proxy for climate change in Turkey. The selected time period also covers important socio-economic events in Turkey such as the coup d'état (1984), economic crises in 1990, 1994, 2000, 2001, 2009 and 2018-23 currency and debt crisis, Iraq war (2003-2011), Syrian war (after 2013), the Gezi Park protests (2013), coup attempt (2016) and so on. In this respect, The GPR index, developed by Caldara & Lacoviello (2022), assesses geopolitical risk factors such as terrorism, trade disputes, and political tensions, impacting global transactions and national policies, and is widely used in various studies (Anser *et al.*, 2021; Cengiz & Manga, 2022; Chen *et al.*, 2024; Ma *et al.*, 2022; Saadaoui *et al.*, 2024; Uddin *et al.*, 2023; Wang *et al.*, 2022; Zhao *et al.*, 2023). An increase in GPR correlates with an elevated risk profile in relation to geopolitical events. Conversely, a reduction in GPR is indicative of a diminished risk outlook. Moreover, we selected CO2 emissions in metric tons per capita as an indicator for measuring CO2 emission levels in line with the previous studies (Cengiz & Manga, 2022; Mejia, 2022; Ren *et al.*, 2014; Salahuddin *et al.*, 2018). For empirical analysis, this study applies residual augmented least square-Fourier augmented unit root test (RALS- FADF), fractional Fourier ADL cointegration test (FFADL), and fully modified ordinary least squares (FMOLS). The variables we used in our empirical analyses are presented in Table 1.

Table 1: Variables Used in the Econometric Analysis

Variable	Definition	Data Source
CO_2PC	Carbon emissions (metric tons per capita)	The Global Carbon Budget 2023 (Friedlingstein *et al.*, 2024)
FIN	Financial development index	International Monetary Fund - IMF (2024)
FDI	Share of foreign direct investments in GDP	World Bank - WB (2024)
GPR	Geopolitical risk index	Caldara & Iacoviello (2022)

In this context, we examine the econometric model presented in Equation (1).

$$CO_2PC_t = \beta_0 + \beta_1 FIN_t + \beta_2 FDI_t + \beta_3 JPR_t + u_t \quad (1)$$

where *CO_2PC* is CO_2 emissions (metric tons per capita), *FGI* is financial development index, FDI is foreign direct investments of %GDP, *GPR* is geopolitical risk index, u_t is the error term, β_0 is the constant term, β_1, β_2, and β_3 are the coefficients of the independent variables. The definition, data source, and variables used in the study are presented in Table 1.

Time series data is generally affected by structural shocks. It is therefore essential to take account of structural breaks in unit root and cointegration analyses. Moreover, the procedures of unit root tests and cointegration tests typically require residuals to be normally distributed. In order to circumvent these issues in our analysis, this study applies the residual augmented least square-Fourier augmented unit root test (RALS-FADF) developed by (Yılancı *et al.*, 2019) and the fractional Fourier ADL cointegration test (FFADL).

3.1. Residual Augmented Least Square-Fourier Augmented Unit Root Test (RALS-FADF):

The standard Dickey-Fuller unit root test equation can be presented as follows.

$$y_t = \alpha_t + \rho y_{t-1} + \gamma_t + \varepsilon_t \qquad (1)$$

where the parameter α_t represents a time-varying deterministic term function. To test the null hypothesis (H_0), which posits that the series is unit-rooted, the value of $\rho = 1$ is analysed. However, when the precise form of the deterministic term is unknown, an inaccurately specified deterministic component can produce biased test outcomes. To address this challenge, Enders and Lee (2012) introduced the Fourier approach as a robust method for handling unknown deterministic term functions.

$$\alpha_{(t)} = \alpha_t + \sum_{k=1}^{n} \alpha_k \sin\left(\frac{2\pi kt}{T}\right) + \sum_{k=1}^{n} \beta_k \cos\left(\frac{2\pi kt}{T}\right); \quad n \leq \frac{T}{2} \qquad (2)$$

where n stands for the estimated number of frequencies, while k specifies the number of frequencies, and T indicates the total observations. If the coefficients of trigonometric terms in Equation 2 are not statistically significant, a linear process will occur and the Dickey-Fuller unit root test should be used.

By replacing the Equation 1 into the Model 1, the FADF unit root test equation is obtained:

$$\Delta y_t = \rho y_{t-1} + c_1 + c_2 t + c_3 \sin\left(\frac{2\pi kt}{T}\right) + c_4 \cos\left(\frac{2\pi kt}{T}\right); \; n \leq \frac{T}{2} \qquad 3$$

The critical values for the unit root are not contingent on the coefficients of the Fourier terms or other deterministic terms. Similar to other related tests, the critical values depend exclusively on the frequency parameter (k) and the sample size (T). In this respect, Enders and Lee (2012) introduced a two-step procedure for estimating the extended Dickey-Fuller (DF) regression model incorporating Fourier functions. In the first step, all models corresponding to k values ranging from 1 to 5 are estimated, and the optimal model is identified based on the criterion of the smallest residual sum of squares. Subsequently, the FADF test statistics are calculated using the selected model. The unit root hypothesis is then evaluated by comparing the calculated statistics with the corresponding critical values (Yılancı *et al.*, 2019).

Certain financial variables have skewed distributions, which are generally the result of asymmetrical relationships in the data. Furthermore, some economic time series variables exhibit a combination of distributions, which are typically modelled using regime transition frameworks. In the case that certain nonlinear patterns are identified, relevant nonlinear tests can be performed on the data. However, the RALS technique, developed by Im *et al*. (2014), has the distinct advantage of not requiring prior knowledge of the functional form. Yılancı *et al*. (2019) later proposes a linear strategy that uses ordinary least-squares (OLS) estimation to take advantage of the higher moments of regression residuals, which often depart from normality. This approach eliminates the requirement for nonlinear estimation.

The RALS estimator is obtained as follows;

$$\widehat{w} = [\hat{e}_t^2 - m_2,\ \ \hat{e}_t^3 - m_3 - 3m_{2t}\hat{e}_t],\ \ t = 1, 2, 3, \dots . T \tag{5}$$

where m_2 is the mean of the squared residuals and m_3 is the mean of the cubed residuals. Yılancı *et al*. (2019) argues that adding these two new series to the main model reflects the non-normal errors.

Yılancı et al. (2019) further extends the FADF test equation to include the RALS estimator;

$$\Delta y_t = \ \rho y_{t-1} + c_1 + c_2 t + c_3 \sin\left(\frac{2\pi kt}{T}\right) + c_4 \cos\left(\frac{2\pi kt}{T}\right) + c_5 \widehat{w}_t + \ v_t;\ n \leq \frac{T}{2} \tag{6}$$

The RALS-FADF test statistic (τ_{RFADF}) is obtained by estimating the model obtained as the appropriate model in the second stage by OLS and testing the null hypothesis $\rho = 0$.

Under the null hypothesis (τ_{RFADF}) is the asymptotic distribution of the test statistic is as follows;

$$\tau_{RFADF} \rightarrow \rho . \tau_{FADF} + \sqrt{1 - \rho^2 . Z}$$

Theorem:

The limit distribution of the t statistic of the FADF test is denoted by τ_{RFADF}, while ρ is the long-term correlation between the FADF and the residuals of the RALS-FADF;

$$\hat{\rho}^2 = \frac{\hat{\sigma}_{eu}}{\sigma_e^2 \sigma_u^2}$$

$\rho^2 = 1$ is valid for $FADF = RALS - FADF$. In this case, the critical values of FADF are used instead of the critical values of RALS-FADF.

Subsequently, the RALS-FADF unit root test is regarded as a prominent second-generation test that can address non-normally distributed residuals and permit the incorporation of structural changes into the empirical model. In the RALS-FADF unit root test, the null hypothesis (H_0) postulates that the series exhibit a unit root, whereas the alternative hypothesis (H_1) suggests the presence of stationarity.

3.2. Fractional Fourier ADL Cointegration Test:

3.2.1. Fourier ADL Cointegration Test

The Fourier ADL cointegration test is used to determine the long-term relations between variables. Nevertheless, structural changes are not included in typical cointegration tests (Engle & Granger, 1991; Johansen, 1992). Ignoring structural changes in a model can lead to misspecification and even misleading estimations, as for unit root testing (Nazlioğlu *et al.*, 2016).

The structural shift in macroeconomic variables occurs gradually, as shown by Enders & Lee (2012). Because of this, the novel Fourier ADL cointegration test is employed in this paper under nonlinear breaks identified by the Fourier functions developed by Banerjee *et al.* (2017). In a single-equation ADL model, the Fourier ADL cointegration test looks for unknown multiple breaks in the time series using full information Maximum Likelihood (ML) estimate. As a result, it helps to find structural breaks in the series. Experiments with simulations demonstrate its good size and great power. Considering Enders & Lee (2012), deterministic terms using Fourier's approach are defined as follows:

$$d(t) = \gamma_0 + \sum_{k=1}^{q} \gamma_{1k} \sin\left(\frac{2\pi kt}{T}\right) + \sum_{k=1}^{q} \gamma_{2,k} \cos\left(\frac{2\pi kt}{T}\right); \;\; q \leq \frac{T}{2} \qquad (7)$$

where γ0 refers to deterministic terms such as constant and trend; k refers to the number of frequencies; and T refers to the number of observations. The ADL equation proposed by Banerjee *et al.* (2017) can be re-estimated by adding Fourier terms as follows:

$$\Delta y_t = d(t) + \delta_1 y_{1,t-1} + \gamma' x_{1,t-1} + \varphi' \Delta x_t + \varepsilon_t$$

δ, γ, φ are nx1 sized parameters while y, x and Δx are explanatory variables. While the null hypothesis of the test suggests that the cointegration relationship does not exist, the alternative hypothesis considers the existence of a long-run relationship.

3.2.2. Fractional Fourier ADL Cointegration test

This test is first developed by Banerjee, Arčabić & Lee (2017) and later improved by İlkay, Yılancı, Ulucak & Jones (2021) who has enabled to add fractional number (k) in Fourier ADL cointegration model to calculate trigonometric terms. The fractional frequency number offers much information on the persistence of structural changes. In standard Fourier-based cointegration tests, the frequency number k is assigned an integer value ranging from 1 to 5. İlkay *et al.* (2021) used the Fractional Fourier ADL cointegration test with the permanent breaks presented by Christopoulos & Leon-Ledesma (2010) to show that these findings reflect a temporary structural change. However, in this approach, the frequency number can have fractional values ranging from 0.1 to 5, allowing for a more thorough investigation of structural alterations that includes both transitory and permanent shifts. The null hypothesis is equivalent to the Fourier ADL cointegration test. The test statistic for the test is computed as follows:

$$t_{ADL} = \frac{\hat{\delta}_1}{se(\hat{\delta}_1)}$$

The main benefit of this test compared to traditional cointegration tests is its ability to detect both gradual and sudden breaks without requiring the predetermined establishment of the form, location, or quantity of these breaks. The critical values required for the Fourier ADL cointegration test were obtained by 100,000 Monte Carlo (MC) simulations, using fractional frequencies.

In this approach, while the null hypothesis (H_0) of the test suggests that the series are cointegrated, the alternative hypothesis (H_1) considers the existence of no-cointegration.

3.2.3. Fully Modified Ordinary Least Squares (FMOLS) estimator

The Fully Modified Least Squares (FMOLS) estimator was developed by Phillips & Hansen (1990) to perform optimal cointegrating regression estimation. This procedure produces asymptotically median unbiased estimators, thus allowing optimal long-run cointegrating regression estimation. The FMOLS estimator requires that all variables be integrated to order one (I(1)). According to Phillips (1995), the FMOLS corrects for serial correlation and long-run endogeneity using semi-parametric corrections. This approach also uses kernel estimators to eliminate the effect of deviation in long-term relationship equations (Phillips & Hansen, 1990).

4. Empirical Results

The analysis has been conducted with the aim of examining the effect of geopolitical risk, foreign direct investments and financial development on CO_2 emissions for Turkey using advanced econometric analysis. It is crucial to test the degree of integration of variables in order to select the most appropriate method and to prevent erroneous results. Therefore, we have identified the optimal integration order using the RALS-FADF unit root test, which outperforms the first-generation unit root tests. The RALS-FADF unit root test has the null-hypothesis (H_0) stating that the series are unit-rooted We report the findings from the RALS-FADF unit root test in Table 2.

Table 2: RALS-FADF Unit Root Test Results

Variables	Constant Model (Level)					
	k	Optimal lags	RALS-FADL	FADL	ρ^2	MinSSR
CO_2PC	1	9	-3.13	-3.40	0.95	1.07
FIN	1	8	-3.30	-4.02	0.97	0.02
FDI	1	1	-3.83	-4.05	0.88	9.24
GPR	1	4	-4.50	-4.20	0.85	0.32
Variables	**Constant Model (1st Difference)**					
ΔCO_2PC	4	2	-5.58*	-5.38	0.92	1.04

ΔFIN	5	1	-5.34*	-5.40	0.89	0.02
ΔFDI	5	0	-7.52*	-5.85	0.83	11.25
ΔGPR	3	2	-5.42*	-5.63	0.94	0.41

Note: *, **, *** indicate that the null hypothesis (unit root) is rejected at 1%, 5%, and 10% significance levels, respectively. The critical values for the Fourier RALS-ADF Unit Root Test for the constant model can be found in the paper by Yılancı, Aydın & Aydın (2019).

Table 2 shows that all of the variables are stationary in first difference. Thus, we propose that all variables be integrated at order one, I(1), allowing us to use the fractional Fourier ADL cointegration technique.

The third phase of the analysis is the identification of cointegrating relationships between selected variables. This study adopts the fractional Fourier ADL cointegration test, which permits the utilisation of fractional k-numbers, to ascertain the long-run relationship between variables. The outcomes of this test are presented in Table 3.

Table 3: Fractional Fourier ADL Cointegration Test Results (Model with Constant)

Test	Dependent Variable	Independent Variables	k	Min AIC	Fractional Fourier ADL Cointeg-Stats
Fourier ADL Cointegration	CO_2PC	FIN, FDI, GPR	1	-1.18	-6.97*
Fractional Fourier ADL Cointegration	CO_2PC	FIN, FDI, GPR	1.1	-1.19	-7.02*

Optimal Lags

CO_2PC	FIN	FDI	GPR
1	4	4	1

Note: *, **, *** indicate that the null hypothesis (unit root) is rejected at 1%, 5%, and 10% significance levels, respectively. The test statistics for Fourier ADL cointegration and Fractional Fourier ADL cointegration tests are compared with Critical Values tabulated in Banerjee *et al.* (2017) and İlkay *et al.* (2021), respectively.

The empirical outcomes tabulated in Table 3 reveal that the estimated coefficients are statistically significant. This evidence allows us to conclude that there exists co-integration among the selected variables, as we can reject the null hypothesis (H_0). In other words, the series move together in the long run, and a long-run analysis with the series in levels will not include spurious regression.

Subsequently, the FMOLS estimator extended with Fourier trigonometric terms was employed to retrieve the short-run (SR) and long-run (LR) estimates, following the confirmation of a cointegration relationship. This method permits the incorporation of structural changes into the empirical model. The results of the FMOLS analysis are presented in Table 4.

Table 4. Long-run Coefficients

Dependent Variable: CO_2PC				
Method	**Independent Variables**	**Coefficients**	**Test Statistics(t)**	**Prob.**
FMOLS	C	0.85*	5.00	0.000
	FDI	0.11***	1.89	0.066
	FIN	7.20*	14.37	0.000
	GPR	0.78**	2.35	0.025
	SIN	0.14***	1.86	0.070
	COS	0.16*	2.92	0.006

Note: *, **, *** indicate that the variables are statistically significant at 1%, 5%, and 10% significance levels, respectively.

The empirical outcomes tabulated in Table 4 indicate that the estimated long-run coefficients of the variables are statistically significant ($p<0.10$). The findings reveal that the foreign direct investment is positively related to the CO_2 emissions, which demonstrates that an increase in the foreign direct investment leads to environmental degradation. In other words, a rise in the foreign direct investment by 1% causes a surge in environmental pollution by 0.11% in the long run. This outcome is consistent with previous studies (Balıbey, 2015; Balsalobre-Lorente *et al.*, 2023; Bildirici, 2021; Şeker *et al.*, 2015) and suggests that the foreign direct investment to Turkey may have contributed to the transfer of polluting technologies and the exploitation of natural resources, which in turn has increased the demand for energy and the CO_2 emissions.

With regard to the potential environmental effect of the financial development, the results appear to indicate a statistically significant and positive relationship with environmental degradation in Turkey. A 1% increase in the financial development is associated with a notable of 7.2% rise in the level of the CO_2 emissions in Turkey over time. It seems that the financial development may not be an effective mitigation measure in reducing the level of the environmental degradation in Turkey. This could be due to the fact that financial development has led to increased economic activity, which in turn has caused higher CO_2 emissions. This finding is consistent with the empirical results in the previous studies (Ahmad *et al.*, 2018; Amri, 2018; Anwar *et al.*, 2022; Atsu *et al.*, 2021; Boutabba, 2014; Farhani & Ozturk, 2015; Gill *et al.*, 2019; Lu, 2018; Mahalik & Mallick, 2014; Park *et al.*, 2018; Shahbaz *et al.*, 2016; Xu *et al.*, 2018; Zhang, 2011).

Finally, the geopolitical risk has a significant impact on the growth of the CO_2 emissions, with a 1% increase in the geopolitical risk leading to a 0.78% increase in environmental degradation over the analysis period. This highlights the potential for political instability to exacerbate environmental problems, particularly in conflict-prone regions where military activities can disrupt energy markets and increase reliance on fossil fuels. These results are in line with the findings of the recent studies by Anser *et al.* (2021), Cengiz & Manga (2022), Ma *et al.* (2022), and Wang *et al.* (2022), Uddin *et al.* (2023), Zhao *et al.* (2023), Saadaoui *et al.* (2024), and Chen *et al.* (2024).

The empirical results indicate that Turkey, a developing economy, should prioritize the use of clean energy sources. The country has already established goals related to renewable energy, including the reduction of environmental harm and the shift to solar and wind power. Therefore, by pursuing these goals and allocating resources to renewable energy sources, specifically by increasing the production of solar and wind power, Turkey will be able to mitigate environmental damage and achieve its environmental and eventually economic goals.

5. Conclusion and Discussion

To the best of our knowledge, no previous empirical study has examined the impact of financial development, geopolitical risk, and foreign direct investment on carbon emissions (CO2) in Turkey from 1985 to 2022. The literature on this topic is very scarce. Our empirical findings, which are specific to Turkey, are critical for informing Turkey's environmental sustainability policymaking.

The findings of the FFADL test demonstrate a long-term positive correlation between the four variables under examination, namely the FDI, FIN, GPR and CO_2 emissions in Turkey. This implies that foreign direct investment, financial development and geopolitical risk have a statistically significant influence on environmental degradation in Turkey, which is consistent with the findings of previous studies for some countries in the literature such as Zhang (2011), Sadorsky (2011), Boutabba (2014), Farhani & Ozturk (2015), Shahbaz *et al.* (2016), Saud & Chen (2018), Salahuddin *et al.* (2018), Le & Öztürk (2020), Guru & Yadav (2019), Samour *et al.* (2019), Yang (2019), Anser *et al.* (2021), Wang *et al.* (2022), Uddin *et al.* (2023), Zhao *et al.* (2023), Saadaoui *et al.* (2024), Ali, Jianguo & Kırıkkaleli (2023), and Chen *et al.*, (2024).

A positive correlation has been observed between foreign direct investment (FDI) and carbon dioxide (CO_2), indicating a need for the implementation of more sustainable economic development strategies that prioritise environmental protection, particularly in Turkey. While FDI has undoubtedly contributed to economic growth and job creation, the environmental impacts of such investments warrant attention. We suggest that policymakers should prioritise sustainable development and encourage foreign investors to adopt more environmentally conscious approaches.

The evidence from Turkey demonstrates a positive correlation between financial development and environmental deterioration. We posit that there is an urgency for the implementation of more sustainable financial policies that prioritise environmental protection. While financial development has undeniably facilitated economic expansion, it is essential to evaluate the potential environmental implications of such policies. Additionally, this paper proposes that policy-makers should prioritise the development of environmentally conscious financial policies and encourage financial institutions to adopt more environmentally-friendly practices. One possible avenue for achieving this could be to prioritize finance-based innovation policies while concomitantly attempting to mitigate the deleterious effects of polluting technologies.

The positive correlation between geopolitical risk and CO_2 emissions in Turkey suggests the potential for more sustainable geopolitical strategies that prioritize environmental protection. While geopolitical risk is an unavoidable phenomenon, it is crucial to assess the potential environmental consequences of such risks. We opine that Turkish policymakers may wish to consider prioritising sustainable geopolitical strategies and encouraging international cooperation in order to mitigate the environmental impacts of geopolitical risk.

In conclusion, the study contributes to the body of knowledge on environmental degradation, offering valuable insights for policymakers and regulators. It is proposed that a comprehensive approach is necessary to address the adverse effects of the foreign direct investment, financial development and geopolitical risk on the CO_2 emissions in Turkey. We recommended that policymakers create energy policies and sustainable development strategies that are aligned with the United Nations' 2030 Sustainable Development Goals. This can be achieved by considering the potential environmental consequences of economic activities and investments, and by balancing economic growth with environmental protection.

References

Abbasi, F., & Riaz, K. (2016). CO2 Emissions and Financial Development in an Emerging Economy: An Augmented VAR Approach. *Energy Policy, 90*, 102-114. https://doi.org/10.1016/j.enpol.2015.12.017

Ali, K., Jianguo, D. & Kırıkkaleli, D. (2023). How Do Energy Resources and Financial Development Cause Environmental Sustainability?. *Energy Reports*, *9*, 4036-4048. https://doi.org/10.1016/j.egyr.2023.03.040

Ahmad, M., Khan, Z., Ur Rahman, Z. & Khan, S. (2018). Does Financial Development Asymmetrically Affect CO_2 Emissions in China? An Application of the Nonlinear Autoregressive Distributed Lag (NARDL) Model. *Carbon Management*, *9*(6), 631-644. https://doi.org/10.1080/17583004.2018.1529998

Alsagr, N. & Van Hemmen, S. (2021). The Impact of Financial Development and Geopolitical Risk on Renewable Energy Consumption: Evidence from Emerging Markets. *Environmental Science and Pollution Research*, *28*(20), 25906-25919. https://doi.org/10.1007/s11356-021-12447-2

Amri, F. (2018). Carbon Dioxide Emissions, Total Factor Productivity, ICT, Trade, Financial Development, and Energy Consumption: Testing Environmental Kuznets Curve Hypothesis for Tunisia. *Environmental Science and Pollution Research*, *25*(33), 33691-33701. https://doi.org/10.1007/s11356-018-3331-1

Anser, M. K., Syed, Q. R. & Apergis, N. (2021). Does Geopolitical Risk Escalate CO2 Emissions? Evidence from the BRICS Countries. *Environmental Science and Pollution Research*, *28*(35), 48011-48021. https://doi.org/10.1007/s11356-021-14032-z

Anwar, A., Sinha, A., Sharif, A., Siddique, M., Irshad, S., Anwar, W. & Malik, S. (2022). The Nexus Between Urbanization, Renewable Energy Consumption, Financial Development, And

CO2 Emissions: Evidence from Selected Asian Countries. *Environment, Development and Sustainability*, *24*(5), 6556-6576. https://doi.org/10.1007/s10668-021-01716-2

Assi, A. F., Zhakanova Isiksal, A. & Tursoy, T. (2021). Renewable Energy Consumption, Financial Development, Environmental Pollution, and Innovations in the ASEAN+3 Group: Evidence from (P-ARDL) Model. *Renewable Energy*, *165*, 689-700. https://doi.org/10.1016/j.renene.2020.11.052

Atsu, F., Adams, S. & Adjei, J. (2021). ICT, Energy Consumption, Financial Development, and Environmental Degradation in South Africa. *Heliyon*, *7*(7), e07328. https://doi.org/10.1016/j.heliyon.2021.e07328

Balıbey, M. (2015). Relationships Among CO2 Emissions, Economic Growth and Foreign Direct Investment and the Environmental Kuznets Curve Hypothesis in Turkey. *International Journal of Energy Economics and Policy*, *5*(4), 1042-1049. https://www.econjournals.com/index.php/ijeep/article/view/1462/906

Balsalobre-Lorente, D., Topaloglu, E. E., Nur, T. & Evcimen, C. (2023). Exploring the Linkage Between Financial Development and Ecological Footprint in APEC Countries: A Novel View Under Corruption Perception and Environmental Policy Stringency. *Journal of Cleaner Production*, *414*, 137686. https://doi.org/10.1016/j.jclepro.2023.137686

Banerjee, P., Arčabić, V. & Lee, H. (2017). Fourier ADL Cointegration Test to Approximate Smooth Breaks with New Evidence from Crude Oil Market. *Economic Modelling, 67*, 114-124. Doi: 10.1016/j.econmod.2016.11.004

Bildirici, M. E. (2021). Terrorism, Environmental Pollution, Foreign Direct Investment (FDI), Energy Consumption, and Economic Growth: Evidences from China, India, Israel, and Turkey. *Energy & Environment*, *32*(1), 75-95. https://doi.org/10.1177/0958305X20919409

Boutabba, M. A. (2014). The Impact of Financial Development, Income, Energy and Trade on Carbon Emissions: Evidence from the Indian Economy. *Economic Modelling*, *40*, 33-41. https://doi.org/10.1016/j.econmod.2014.03.005

Byrne, B., Baker, D.F., Basu, S., Bertolacci, M., Bowman, K.W., Carroll, D., Chatterjee, A., Chevallier, F., Ciais, P., Cressie, N., Crisp, D., Crowell, S., Deng, F., Deng, Z., Deutscher, N.M., Dubey, M.K., Feng, S., García, O.E., Griffith, D.W.T., Herkommer, B., Hu, L., Jacobson, A.R., Janardanan, R., Jeong, S., Johnson, M.S., Jones, D.B.A., Kivi, R., Liu, J., Liu, Z., Maksyutov, S., Miller, J.B., Miller, S.M., Morino, I., Notholt, J., Oda, T., O'Dell, C.W., Oh, Y.-S., Ohyama, H., Patra, P.K., Peiro, H., Petri, C., Philip, S., Pollard, D.F., Poulter, B., Remaud, M., Schuh, A., Sha, M.K., Shiomi, K., Strong, K., Sweeney, C., Té, Y., Tian, H., Velazco, V.A., Vrekoussis, M., Warneke, T., Worden, J.R., Wunch, D., Yao, Y., Yun, J., Zammit-Mangion, A. & Zeng, N. (2023). National CO_2 Budgets (2015-2020) Inferred from Atmospheric CO_2 Observations in Support of the Global Stocktake. *Earth System Science Data, 15,* 963-1004. https://doi.org/10.5194/essd-15-963-2023

Caldara, D. & Iacoviello, M. (2022). Measuring Geopolitical Risk. *American Economic Review, 112*(4), 1194-1225.

Caruso, G., Colantonio, E. & Gattone, S. A. (2020). Relationships between Renewable Energy Consumption, Social Factors, and Health: A Panel Vector Auto Regression Analysis of a Cluster of 12 EU Countries. *Sustainability*, *12*(7), 2915. https://doi.org/10.3390/su12072915

Cengiz, O. & Manga, M. (2022). Is There Any Relationship Between Geopolitical Risk and Climate Change?. *Ekonomski Vjesnik*, *35*(1), 99-112. https://doi.org/10.51680/ev.35.1.8

Chen, L., Gozgor, G., Lau, C. K. M., Mahalik, M. K., Rather, K. N. & Soliman, A. M. (2024). The Impact of Geopolitical Risk on CO2 Emissions Inequality: Evidence From 38 Developed and Developing Economies. *Journal of Environmental Management*, *349*, 119345. https://doi.org/10.1016/j.jenvman.2023.119345

Coşkuner, C., Paskeh, M. K., Olasehinde-Williams, G. & Akadiri, S. S. (2020). Economic and Social Determinants of Carbon Emissions: Evidence from Organization of Petroleum Exporting Countries. *Journal of Public Affairs*, *20*(3), e2092. https://doi.org/10.1002/pa.2092

Ding, Y., Yang, Q. & Cao, L. (2021). Examining The Impacts of Economic, Social, and Environmental Factors on the Relationship Between Urbanization and CO2 Emissions. *Energies*, *14*(21), 7430. https://doi.org/10.3390/en14217430

Essandoh, O. K., Islam, M. & Kakinaka, M. (2020). Linking International Trade and Foreign Direct Investment to CO2 Emissions: Any Differences Between Developed and Developing Countries?. *Science of The Total Environment*, *712*, 136437. https://doi.org/10.1016/j.scitotenv.2019.136437

Farhani, S. & Ozturk, I. (2015). Causal Relationship Between CO2 Emissions, Real GDP, Energy Consumption, Financial Development, Trade Openness, and Urbanization in Tunisia. *Environmental Science and Pollution Research*, *22*(20), 15663-15676. https://doi.org/10.1007/s11356-015-4767-1

Friedlingstein, P., O'Sullivan, M., Jones, M. W., Andrew, R. M., Bakker, D. C. E., Hauck, J., Landschützer, P., Le Quéré, C., Luijkx, I. T., Peters, G. P., Peters, W., Pongratz, J., Schwingshackl, C., Sitch, S., Canadell, J. G., Ciais, P., Jackson, R. B., Alin, S. R., Anthoni, P., Barbero, L., Bates, N. R., Becker, M., Bellouin, N., Decharme, B., Bopp, L., Brasika, I. B. M., Cadule, P., Chamberlain, M. A., Chandra, N., Chau, T.-T.-T., Chevallier, F., Chini, L. P., Cronin, M., Dou, X., Enyo, K., Evans, W., Falk, S., Feely, R. A., Feng, L., Ford, D. J., Gasser, T., Ghattas, J., Gkritzalis, T., Grassi, G., Gregor, L., Gruber, N., Gürses, Ö., Harris, I., Hefner, M., Heinke, J., Houghton, R. A., Hurtt, G. C., Iida, Y., Ilyina, T., Jacobson, A. R., Jain, A., Jarníková, T., Jersild, A., Jiang, F., Jin, Z., Joos, F., Kato, E., Keeling, R. F., Kennedy, D., Klein Goldewijk, K., Knauer, J., Korsbakken, J. I., Körtzinger, A., Lan, X., Lefèvre, N., Li, H., Liu, J., Liu, Z., Ma, L., Marland, G., Mayot, N., McGuire, P. C., McKinley, G. A., Meyer, G., Morgan, E. J., Munro, D. R., Nakaoka, S.-I., Niwa, Y., O'Brien,

K. M., Olsen, A., Omar, A. M., Ono, T., Paulsen, M., Pierrot, D., Pocock, K., Poulter, B., Powis, C. M., Rehder, G., Resplandy, L., Robertson, E., Rödenbeck, C., Rosan, T. M., Schwinger, J., Séférian, R., Smallman, T. L., Smith, S. M., Sospedra-Alfonso, R., Sun, Q., Sutton, A. J., Sweeney, C., Takao, S., Tans, P. P., Tian, H., Tilbrook, B., Tsujino, H., Tubiello, F., Van Der Werf, G. R., Van Ooijen, E., Wanninkhof, R., Watanabe, M., Wimart-Rousseau, C., Yang, D., Yang, X., Yuan, W., Yue, X., Zaehle, S., Zeng, J. & Zheng, B. (2023). Global Carbon Budget 2023. *Earth Syst. Sci. Data 15*, 5301-5369. https://doi.org/10.5194/essd-15-5301-2023

Gill, A. R., Hassan, S. & Haseeb, M. (2019). Moderating Role of Financial Development in Environmental Kuznets: A Case Study of Malaysia. *Environmental Science and Pollution Research*, *26*(33), 34468-34478. https://doi.org/10.1007/s11356-019-06565-1

Guru, B. K. & Yadav, I. S. (2019). Financial Development and Economic Growth: Panel Evidence from BRICS. *Journal of Economics, Finance and Administrative Science*, *24*(47), 113-126. https://doi.org/10.1108/JEFAS-12-2017-0125

Habiba, U. & Xinbang, C. (2022). The Impact of Financial Development on CO2 Emissions: New Evidence from Developed and Emerging Countries. *Environmental Science and Pollution Research*, *29*(21), 31453-31466. https://doi.org/10.1007/s11356-022-18533-3

Hao, Y. & Liu, Y.-M. (2015). Has the Development of FDI and Foreign Trade Contributed to China's CO2 Emissions? An Empirical Study with Provincial Panel Data. *Natural Hazards*, *76*(2), 1079-1091. https://doi.org/10.1007/s11069-014-1534-4

İmamoğlu, İ. K. (2023). Sürdürülebilir Ekonomik Büyüme, Jeopolitik Risk ve Çevre Performansı: ABD Ekonomisinden Kanıtlar. *Asya Studies*, *7*(25), 245-258. https://doi.org/10.31455/asya.1336189

IEA (International Energy Agency). (2024). Türkiye-Countries & Regions. *IEA*. https://www.iea.org/countries/turkiye. [Accessed: 17/03/2024].

Khan, M. A., Khan, M. Z., Zaman, K. & Arif, M. (2014). Global Estimates of Energy-Growth Nexus: Application of Seemingly Unrelated Regressions. *Renewable and Sustainable Energy Reviews*, *29*, 63-71. https://doi.org/10.1016/j.rser.2013.08.088

Koçak, E. & Şarkgüneşi, A. (2017). The Renewable Energy and Economic Growth Nexus in Black Sea and Balkan Countries. *Energy Policy, 100*, 51-57. https://doi.org/10.1016/j.enpol.2016.10.007

Koçak, E. & Şarkgüneşi, A. (2018). The Impact of Foreign Direct Investment on CO2 Emissions in Turkey: New Evidence from Cointegration and Bootstrap Causality Analysis. *Environmental Science and Pollution Research*, *25*(1), 790-804. https://doi.org/10.1007/s11356-017-0468-2

Li, R., Wang, Q., Liu, Y. & Jiang, R. (2021). Per-Capita Carbon Emissions in 147 Countries: The Effect of Economic, Energy, Social, and Trade Structural Changes. *Sustainable*

Production and Consumption, *27*, 1149-1164. https://doi.org/10.1016/j.spc.2021.02.031

Lu, W. C. (2018). The Impacts of Information and Communication Technology, Energy Consumption, Financial Development, and Economic Growth on Carbon Dioxide Emissions in 12 Asian Countries. *Mitigation and Adaptation Strategies for Global Change*, *23*(8), 1351-1365. https://doi.org/10.1007/s11027-018-9787-y

Lv, Z. & Li, S. (2021). How Financial Development Affects CO2 Emissions: A Spatial Econometric Analysis. *Journal of Environmental Management*, *277*, 111397. https://doi.org/10.1016/j.jenvman.2020.111397

Ma, W., Nasriddinov, F., Haseeb, M., Ray, S., Kamal, M., Khalid, N. & Ur Rehman, M. (2022). Revisiting the Impact of Energy Consumption, Foreign Direct Investment, and Geopolitical Risk on CO2 Emissions: Comparing Developed and Developing Countries. *Frontiers in Environmental Science*, *10*, 985384. https://doi.org/10.3389/fenvs.2022.985384

Mahalik, M. K. & Mallick, H. (2014). Energy Consumption, Economic Growth and Financial Development: Exploring the Empirical Linkages for India. *The Journal of Developing Areas*, *48*(4), 139-159. https://doi.org/10.1353/jda.2014.0063

Mejia, S. A. (2022). Foreign Direct Investment and the Environment: A Cross-National Analysis of Carbon Dioxide Emissions Per Capita, 1980-2018. *Sociological Forum*, *37*(4), 1108-1130. https://doi.org/10.1111/socf.12859

Nazlioğlu, S., Gormus, N. A. & Soytas, U. (2016). Oil Prices and Real Estate Investment Trusts (Reits): Gradual-Shift Causality and Volatility Transmission Analysis. *Energy Economics*, *60*, 168-175. https://doi.org/10.1016/j.eneco.2016.09.009

Omri, A., Daly, S., Rault, C. & Chaibi, A. (2015). Financial Development, Environmental Quality, Trade and Economic Growth: What Causes What in MENA Countries. *Energy Economics*, *48*, 242-252. https://doi.org/10.1016/j.eneco.2015.01.008

Park, Y., Meng, F. & Baloch, M. A. (2018). The Effect of ICT, Financial Development, Growth, and Trade Openness on CO2 Emissions: An Empirical Analysis. *Environmental Science and Pollution Research*, *25*(30), 30708-30719. https://doi.org/10.1007/s11356-018-3108-6

Ren, S., Yuan, B., Ma, X. & Chen, X. (2014). International Trade, FDI (foreign direct investment) and Embodied CO2 Emissions: A Case Study of Chinas Industrial Sectors. *China Economic Review*, *28*, 123-134. https://doi.org/10.1016/j.chieco.2014.01.003

Saadaoui, H., Dogan, M. & Omri, E. (2024). The Impacts of Hydroelectricity Generation, Financial Development, Geopolitical Risk, Income, and Foreign Direct Investment on Carbon Emissions in Turkey. *Environmental Economics and Policy Studies*, *26*(2), 239-261. https://doi.org/10.1007/s10018-023-00384-y

Sadorsky, P. (2011). Financial Development and Energy Consumption in Central and Eastern European Frontier Economies. *Energy Policy*, *39*(2), 999-1006. https://doi.org/10.1016/j.enpol.2010.11.034

Salahuddin, M., Alam, K., Ozturk, I. & Sohag, K. (2018). The Effects of Electricity Consumption, Economic Growth, Financial Development and Foreign Direct Investment on CO2 Emissions in Kuwait. *Renewable and Sustainable Energy Reviews*, *81*, 2002-2010. https://doi.org/10.1016/j.rser.2017.06.009

Samour, A., Zhakanova Isiksal, A. & Gunsel Resatoglu, N. (2019). Testing the Impact of Banking Sector Development on Turkey's CO2 Emissions. *Applied Ecology and Environmental Research*, *17*(3). https://doi.org/10.15666/aeer/1703_64976513

Saud, S., Chen, S., Danish & Haseeb, A. (2019). Impact of Financial Development and Economic Growth on Environmental Quality: An Empirical Analysis from Belt and Road Initiative (BRI) Countries. *Environmental Science and Pollution Research*, *26*(3), 2253-2269. https://doi.org/10.1007/s11356-018-3688-1

Shahbaz, M., Shahzad, S. J. H., Ahmad, N. & Alam, S. (2016). Financial Development and Environmental Quality: The Way Forward. *Energy Policy*, *98*, 353-364. https://doi.org/10.1016/j.enpol.2016.09.002

Şeker, F., Ertuğrul, H. M. & Çetin, M. (2015). The Impact of Foreign Direct Investment on Environmental Quality: A Bounds Testing and Causality Analysis for Turkey. *Renewable and Sustainable Energy Reviews*, *52*, 347-356. https://doi.org/10.1016/j.rser.2015.07.118

Tamazian, A., Chousa, J. P. & Vadlamannati, K. C. (2009). Does Higher Economic and Financial Development Lead to Environmental Degradation: Evidence from BRIC Countries. *Energy Policy*, *37*(1), 246-253. https://doi.org/10.1016/j.enpol.2008.08.025

Uddin, I., Usman, M., Saqib, N. & Makhdum, M. S. A. (2023). The Impact of Geopolitical Risk, Governance, Technological Innovations, Energy Use, and Foreign Direct Investment on CO2 Emissions in the BRICS Region. *Environmental Science and Pollution Research*, *30*(29), 73714-73729. https://doi.org/10.1007/s11356-023-27466-4

UNCTAD. (2024). UNCTADstat-General Profile: Türkiye. *UNCTADstat*. https://unctadstat.unctad.org/CountryProfile/GeneralProfile/en-GB/792/index.html). [Accessed: 11/03/2024]

Wang, K. H., Kan, J. M., Jiang, C.-F. & Su, C.-W. (2022). Is Geopolitical Risk Powerful Enough to Affect Carbon Dioxide Emissions? Evidence from China. *Sustainability*, *14*(13), 7867. https://doi.org/10.3390/su14137867

World Bank. (2024). GDP (Current US$)-Turkiye. World Bank National Accounts Data. https://data.worldbank.org/indicator/NY.GDP.MKTP.CD?locations=TR [Accessed: 07/04/2024].

World Bank. (2024). *World Bank Open Data*. https://data.worldbank.org. [Accessed: 07/04/2024].

Xu, Z., Baloch, M. A., Danish, Meng, F., Zhang, J. & Mahmood, Z. (2018). Nexus between Financial Development and CO2 Emissions in Saudi Arabia: Analyzing the Role of Globalization. *Environmental Science and Pollution Research*, *25*(28), 28378-28390. https://doi.org/10.1007/s11356-018-2876-3

Yang, F. (2019). The Impact of Financial Development on Economic Growth in Middle-Income Countries. *Journal of International Financial Markets, Institutions and Money*, *59*, 74-89. https://doi.org/10.1016/j.intfin.2018.11.008

Yılancı, V., Aydın, M. & Aydın, M. (2019). *Residual Augmented Fourier ADF Unit Root Test*. MPRA Paper 96797, University Library of Munich. https://mpra.ub.uni-muenchen.de/96797/

Zhang, Y.-J. (2011). The Impact of Financial Development on Carbon Emissions: An Empirical Analysis in China. *Energy Policy*, *39*(4), 2197-2203. https://doi.org/10.1016/j.enpol.2011.02.026

Zhao, Z., Gozgor, G., Lau, M. C. K., Mahalik, M. K., Patel, G. & Khalfaoui, R. (2023). The Impact of Geopolitical Risks on Renewable Energy Demand in OECD countries. *Energy Economics*, *122*, 106700. https://doi.org/10.1016/j.eneco.2023.106700

Çıkar Beyanı: Yazarlar arasında çıkar çatışması yoktur.

Etik Beyanı: Bu çalışmanın tüm hazırlanma süreçlerinde etik kurallara uyulduğunu yazarlar beyan eder. Aksi bir durumun tespiti halinde Fiscaoeconomia Dergisinin hiçbir sorumluluğu olmayıp, tüm sorumluluk çalışmanın yazarlarına aittir.

Conflict of Interest: The authors declare that they have no competing interests.

Ethical Approval: The authors declare that ethical rules are followed in all preparation processes of this study. In the case of a contrary situation, Fiscaoeconomia has no responsibility, and all responsibility belongs to the study's authors.