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# Pollution Haven Hypothesis: Smooth Quantile Evidence from BRICS

*Kirlilik Cenneti Hipotezi: BRICS'ten Düzleştirilmiş Kantil Kanıtlar*

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**ABSTRACT**

*Pollution, like everything else, can be carried along with globalization. This approach, which refers to the pollution carried by the capital, is the pollution haven hypothesis. This study investigates the effects of foreign direct investment (FDI) on carbon dioxide (Co2) emissions in the BRICS countries from 1992 to 2020. We employed the instrumental variables smooth quantile regression (SIV-QR) method, which is novel in panel econometry. We found that per capita income has an increasing effect on carbon emissions in all estimators with all quantiles. In addition, our findings indicate that FDI flows have a decreasing effect on Co2 in high quantiles. However, the FDI plot estimates of the simultaneous quantile regression show that this has an increasing effect in low quantiles. This means that, at low quantiles, the pollution hypothesis is valid. This can help uncover possible relationships between the routes of money and carbon dioxide emissions.*

***Anahtar Kelimeler:***

*Kirlilik Cenneti,*

*Carbon Dioksit Emisyonları,*

*Düzleştirilmiş Kantil Regresyon*

***Jel Kodları:***

*C02 C30 C44*

**ÖZET**

*Her şey gibi kirlilik de küreselleşmeyle birlikte taşınabilir. Sermayenin taşıdığı kirliliği ifade eden bu yaklaşım, kirlilik cenneti hipotezidir. Bu çalışma, 1992-2020 dönemi için BRICS ülkelerindeki doğrudan yabancı yatırımın (DYY) karbondioksit (Co2) emisyonları üzerindeki etkilerini araştırmaktadır. Çalışmamızda panel ekonometrisinde yeni olan araçsal değişkenli düzleştirilmiş kantil regresyon (SIV-QR) yöntemini kullandık. Kişi başına düşen gelirin, tüm tahmincilerde ve kantillerde karbon emisyonları üzerinde artırıcı bir etkiye sahip olduğunu bulduk. Ayrıca bulgularımız doğrudan yabancı yatırım akışlarının yüksek oranlarda Co2 üzerinde azaltıcı bir etkiye sahip olduğunu göstermektedir. Ancak eş zamanlı kantil regresyonun DYY grafiği tahminleri, bunun düşük kantil dilimlerde artan bir etkiye sahip olduğunu göstermektedir. Bu, düşük kantillerde kirlilik cenneti hipotezinin geçerli olduğu anlamına gelir. Bu bulgular, paranın rotası ile karbondioksit emisyonları arasındaki olası ilişkilerin ortaya çıkarılmasında yardımcı olabilir.*

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## 1. INTRODUCTION

Global warming and the resulting climate crisis are leading global problems in the 21st century. One of the mother-lode feedings in the climate crisis is greenhouse gas and carbon dioxide emissions. Carbon dioxide emissions, which are closely related to the consumption of fossil fuels, are also the subject of trade between regions and countries. It is a cap-and-trade system or an emissions trading system. On the one hand, economic growth is of core importance for the markets. Environmental measures implemented by countries or regional associations can also determine the route of carbon emissions. Globalization has not only mobilized capital but also activated carbon emissions.

One of the issues emphasized in recent years is economic growth, energy consumption, and pollution (Muhammad, 2019; Chang & Li, 2018; Shahbaz et al, 2023). While most studies have focused on economic growth, energy consumption, and pollution, the effects of foreign direct investment flow on pollution have been relatively less researched (Bakhsh et al., 2017). To fill this gap, our study aims to discover the relationship between foreign direct investment, Co2, and economic growth.

Increased environmental awareness in developed countries may affect the geographical location or amount of production. Environmentally friendly policies of developed countries and clean production (Cole, 2004) affect the profitability of production processes through various factors. One way to prevent a possible decline in profit rates is to shift production centers to developing countries with relatively weak environmental policies (Cole, 2004). Apart from this, costs per unit can be reduced with environmentally friendly technologies, and for this reason, developing environmentally friendly production relations with intensive technology is among the possibilities. The second possibility emphasizes the reducing effects of investments in technology on pollution. In other words, this effect is known as the technological effect, in which direct foreign investment flows reduce pollution (Chang & Li, 2018). The first possibility is referred to as the pollution haven hypothesis, or the race to the bottom concept (Dean et al., 2009; Khan & Öztürk, 2020). Although both can be observed in modern economies, this study focuses on the first possibility.

While foreign direct investments, which can also be an indicator of fragility (Abdilabekov & Kaleci, 2020), increase economic growth, it can also increase environmental pollution through industrial activities (Aslan et al., 2021; Khan & Öztürk, 2020; Koçak & Şargüneşi, 2018). Foreign direct investment (FDI) flow, which is currently considered one of the driving forces of economic growth (Nasir et al., 2022), can also be the driving force of an insidious result. Among the mainstream approaches, studies such as French (1998), Cole (2004), Dean et al. (2009), Pao &Tsai (2011), and Omri et al. (2014) are pioneering studies focusing on the effects of foreign direct investments on pollution.

Today, as in the past (Pao & Tsai, 2011), BRICS countries are pioneers of investment destinations in the world. These countries also account for a large share of the world economy in terms of economic growth, energy exports, technology exports, and trade. In addition, since 2006, China has surpassed the USA in terms of $Co_2$ from fossil fuels and industry (OWD, 2023a).

Based on these explanations, this study examines the effects of FDI flows on carbon dioxide emissions in BRICS countries. We employ the instrumental smooth quantile regression method developed by Kaplan & Sun (2017), which can be considered a novel method in panel econometrics. This method smooths the tool function rather than the goal, thereby increasing its reliability compared to other instrumental methods. The modest contributions of our study to the literature are as follows: First, unlike the literature, this study addresses the effects of FDI flows on Co2 in BRICS countries using quantile methods. Second, this study is the first to address the effects of FDI flows on Co2 with the smooth quantile approach in BRICS countries. While our findings indicate increased effects of FDI flows on Co2 in low quantiles, the quantile plot estimates show that this effect turns to decreased effects on high quantiles.

This paper is organized as follows: Section 2 presents recent studies. Section 3 provides information on the datasets, methods, and models. Section 4 presents our findings and discussion. Finally, we conclude the study with policy recommendations.

## 2. LITERATURE REVIEW

Many empirical studies have been conducted on the direction and magnitude of the relationship between Co2 emissions and macroeconomic variables. In addition to carbon dioxide emissions and foreign direct investment, some studies have focused on variables such as economic growth (Xiong & Xu, 2021), exports (Li et al., 2023),

foreign trade (Kander & Lindmark, 2006), imports, and debt (Boly et al., 2022). On the other hand, some studies examined the effects of FDI on industrialization such as Topcu (2016), Adom & Amuakwa-Mensah (2016), Voumik & Ridvan (2023) and Çetin et al (2023). Some studies examined the impact of financial development on environmental issues (Topcu, 2022; Kong et al., 2024; Oanh, 2024).

Among some studies that integrated the FDI variable into the EKC model, Keho (2015) researched the FDI effect on Co2 for West African States. The authors employed Autoregressive Distributed Lagged (ARDL), and their findings obtained with time series differ by country. The effects of FDI on Co2 emissions are negative in some countries and positive in others. Tang & Tan (2015) similarly integrated the EKC and FDI for Vietnam. The authors' findings differ between the short- and long-term. Their findings showed that, while FDI had a reducing effect on Co2 in the long term, it was not statistically significant in the short term. However, according to the causality test results, FDI causes Co2 in the long term.

Peng et al (2016) investigated the causality between FDI and Co2 in China's provinces between 1985 and 2012. Their findings showed one-way causality in some provinces and two-way causality in others. Ali et al (2017) used ARDL and Dynamic Ordinary Least Square (DOLS) methods in their research examining the EKC model and FDI for Malaysia between 1971 to 2013. They found no statistically significant relationship between FDI and Co2. Bakhsh et al. (2017) investigated the effects of FDI on environmental pollution in Pakistan from 1984 to 2014 with a simultaneous equation model. They found that FDI is positively related to pollution.

Behera & Dash (2017) researched FDI impact on Co2 for the 17 countries in the South and Southeast Asian (SSEA) region during the period 1980-2012. They divided the countries into three groups according to their income level. Their findings showed that FDI had an increasing effect on Co2 emissions in high-income and middle-income countries, while it was not statistically significant in low-income countries. Sapkota & Bastola (2017) provide evidence of the increasing pollution effects of FDI on Co2 in a sample of 14 Latin American countries, and Chang & Li (2018) in a sample of 84 countries.

While Koçak & Şarkgüneşi (2018) found increasing effects of FDI on Co2 in Turkey's 1974-2013 period, Haug & Ucal (2019) found no statistically significant relationship for Turkey between 1974-2014. Salahuddin et al. (2018) investigated the effects of FDI on Kuwait using ARDL in the 1980-2013 period. They find that FDI has an increasing effect on Co2. Muhammad & Khan (2019) investigated the Co2 effects of FDI in 34 host countries of Asia and 115 source countries with the GMM method. In addition, Khan & Öztürk (2020), Aslan et al (2021), and Awan et al (2022) found that FDI increases Co2. Essandoh et al. (2020) investigated FDI and Trade effect on Co2 for the developed and developing countries for the period from 1991 to 2014. They used a panel pooled mean group-autoregressive distributive lag (PMG-ARDL) approach and found that Co2 emissions only It reveal that it has a long-term positive relationship with FDI inflows for developing countries. In addition, Liu et al. (2024) examined the effect of China's FDI on environmental issues through Belt and Road countries using the EKC model. They employed second-generation tests, and their findings showed that FDI has a decreasing effect on Co2 in 16 European countries, in contrast to 30 Asian and MENA countries. Also, Marques & Caetano (2020) found that FDI affects emissions differently in high- and middle-income countries. In high-income countries, FDI reduces emissions, whereas in middle-income countries, it increases emissions in the short run. This finding supports the pollution haven hypothesis, which posits that countries with lower environmental standards attract investment by offering lower production costs and weaker regulations, thus leading to higher emissions.

Differing from above, Dhrifi et al. (2020) investigated the effects of FDI on Co2 for 98 developing countries over the period 1995-2017 using simultaneous equations models (SEM's). They separated countries according to their geographical situation, but their global findings showed a bidirectional causal relationship between FDI and Co2. Xie et al (2020) discovered the nonlinear relations ships FDI and Co2 in emerging countries. They found that FDI affected Co2 concentrations differently. Directly, this raises Co2 levels. However, through spillover effects on economic growth, FDI can decrease Co2 concentrations. The total effect of FDI on Co2 leakage changes from positive to negative with increasing FDI inflows, supporting the pollution haven and pollution halo hypotheses. Balsalobre-Lorente et al. (2022) researched the effects of foreign direct investment, economic growth, urbanization, and energy use on carbon emissions in BRICS countries from 1990 to 2014. They employed the FMOLS and DOLS methods. Their findings showed that FDI with energy use generates an increased effect on carbon emissions. Similarly, Mohsin et al (2022) investigated the effect of foreign direct investment, economic growth, energy consumption and personal remittances on carbon emissions in European and Central Asian countries. Their ARDL estimator findings show that FDI Granger causes Co2 emissions, and FDI has a decreased effect in the long run and an increased effect in the short term.

Research on the impact of FDI on carbon dioxide emissions has typically employed either the base EKC or hybrid EKC model as a framework. The outcomes of these studies have been inconsistent and depend on factors such as the period studied, methods employed, and sample sizes used. Additionally, most of the included studies employed linear estimators in their research. It is difficult to generalize the findings of these studies in terms of FDI, but while the effects of FDI on carbon emissions are positive in developed countries, they are negative in developing or emerging economies. Some studies divide the effects of FDI on Co2 into short- and long-term effects. However, the findings are scattered in this regard, and the coefficient signs may differ, regardless of the country's development level. Estimating the relationship between FDI and Co2 using nonlinear methods depending on the business cycle is important because FDI, which is related to both economic growth and global risk, is directly affected by business cycles. However, there is a notable gap in the literature on this subject. This study contributes to the literature in this respect.

## 3. SAMPLE, DATA, MODEL AND METHODOLOGY

This study investigates the effects of FDI flow on Co2 emissions in five emerging economies (Brazil, Russia, India, China, and South Africa (BRICS)). We employ panel data methods in our study. Panel data analysis has many advantages (seen for details Koç & Günay, 2023).

BRIC was first introduced by O'Neill (2001), and South Africa was joined in 2011 (Chatterjee & Naka, 2022). We considered three aspects of BRICS when determining the sample. The first is their attitude towards carbon emissions, the second is their relatively weak environmental policies compared to Europe, and the last is their stability in foreign direct investment inflows.

This study was inspired by the model developed by Omir et al. (2014), Shahbaz et al. (2019), and Salahuddin et al. (2018). We adopted the Bakhsh et al. (2017) time-series model for the panel estimation. The functional definition is as follows and Equation 2:

$$Co2 = f(GDP, FDI) \tag{1}$$

$$\ln Co_{2_{it}} = a_0 + \beta_1 \ln Gdp_{it} + \beta_2 \ln Fdı_{it} + \varepsilon_{it} \tag{2}$$

Equation 2 is a double-log model where Co2 is carbon dioxide emissions per capita, Gdp is gross domestic product per capita (constant, 2015 US$), FDI is foreign direct investment, net inflow (% of GDP), and ε is the error term. In addition, we used two instrumental variables (electricity consumption and population density) in our model. The definitions, abbreviations, and sources of variables are listed in Table 1.

**Table 1.** Data Information

| Variable | Definition | Unit | Data source |
|---|---|---|---|
| Co2 | Carbon dioxide emissions | Co2 per capita | OWD (2023a) |
| Eu | Energy consumptions | Primary energy consumption per capita (kWh/person) | OWD (2023b) |
| Gdp | Gross Domestic Product | GDP per capita (constant 2015 US$) | WDI (2023) |
| Fdı | Foreign direct investment | Foreign direct investment, net inflows (% of GDP) | |
| Pop | Population density | Population density (people per sq. km of land area) | |

In the economic approach, one of the main issues in creating a model is the use of exogenous and instrumental variables. In a model, some variables can be explained by other variables while some variables cannot be explained by other variables. To take this into account, we assume that GDP is endogenous and FDI exogenous. Considering that GDP can be explained by different variables, instrumental variables are also included in the model. These are energy consumption and population density.

In the current study, which is based on foreign direct investments and economic growth, we used an effective method that theoretically considers endogenous and exogenous. For this purpose, we prefer a novel method recently developed in panel econometrics. Kaplan & Sun (2017) developed smoothed quantile estimating equations, a quantile method that allows the use of instrumental data. In this method, instrumental variables quantile regression was added, and the authors developed it to smooth the indicator function (namely, SIV-QR).

SIV-QR has some advantages as a kernel-based nonparametric conditional quantile estimator. i) This method can be easily calculated using a standard iterative algorithm that requires smoothness; ii) owing to the smoothing estimator of SIV-QR, the method has high-order properties; iii) SIV-QR is a flexible set of estimators that includes

IV/OLS mean regression estimators and median and quantitative regression estimators; and iv) SIV-QR reduces the mean square error, which creates more powerful tests (see for detail Kaplan & Sun (2017)).

## 4. EMPIRICAL FINDINGS

Table 2 presents descriptive statistics. Eu and Gdp means are higher than others respectively. The standard divisions of Co2 and Fdı are lower than the rest. Skewness shows that only Gdp is positively skewed, while the others are negatively skewed.

**Table 2.** Descriptive Statistics

| | Mean | Std. Dev. | Min. | Max. | Skewness | Kurtosis |
|---|---|---|---|---|---|---|
| Co2 | 5.52 | 3.88 | .72 | 13.2 | .262 | 1.50 |
| Gdp | 5254.0 | 2923.1 | 546.4 | 10358.2 | -.16 | 1.83 |
| Fdı | 2.11 | 1.45 | .002 | 6.18 | .55 | 2.42 |
| Pop | 120.5 | 145.2 | 8.71 | 469.65 | 1.25 | 3.08 |
| Eu | 23135.2 | 17312.9 | 2812.7 | 64323.9 | .84 | 2.51 |

While the kurtosis value belonging to Pop is about mesokurtic (normal distribution), Co2, Gdp, and Eu are leptokurtic (T-distributions) and platykurtic (uniform distributions). Therefore, most variables did not have a normal distribution. Therefore, nonparametric methods may be more effective for our estimations.

**Table 3.** Partial Correlations of Carbon Dioxide Emission

| | Partial Corr. | Semi partial | Partial Corr$^2$ | Significance Value |
|---|---|---|---|---|
| lnGdp | -0.59 | -0.11 | 0.35 | 0.0000 |
| lnFdı | -0.17 | -0.02 | 0.03 | 0.0382 |
| lnEu | 0.97 | 0.681 | 0.95 | 0.0000 |
| lnPop | 0.80 | 0.208 | 0.65 | 0.0000 |

While the partial correlation results provide some proof of the effects of Gdp and Fdı flow on Co2, the fact that we received confirmed findings with the semi-partial results provides key information about the explanatory power of the control variables. Figure 1 shows the estimation results of the function in Equation 1 by weighted least-squares regression, with the weighted versions of lnFdı (left) and lnGdp (right).

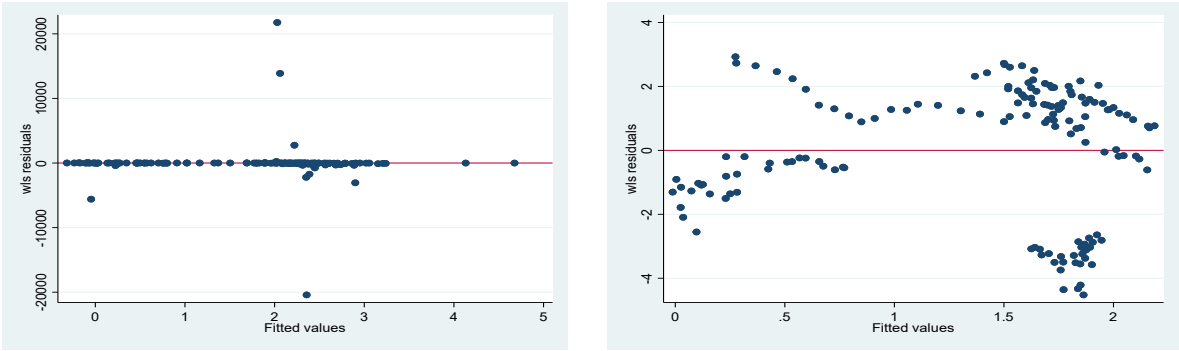


**Figure 1.** Weighted Least Squares Estimate Plots

Accordingly, the correlation between lnFdı (left) and Co2 appears strong. On the other hand, lnGdp (right) indicates a relatively weak and volatile relationship.

**Table 4.** SIV-QR and IV-2SLS Results

| Dependent Variable: lnCo2 | 2SLS | SIV-QR | | | | |
|---|---|---|---|---|---|---|
| | | Q10 | Q25 | Q50 | Q75 | Q90 |
| lnGdp | 1.07[a] | .68 | .96[a] | 1.09[a] | 1.16[a] | 1.19[a] |
| lnFdı | -.17[a] | -.20 | -.16 | -.09[b] | -.09[a] | -.04[b] |
| Constant | -7.49[a] | -5.24 | -6.74[a] | -7.45[a] | -7.79[a] | -7.8[a] |
| $R^2$ | 0.4130 | --- | --- | --- | --- | --- |

| | | | | | | |
|---|---|---|---|---|---|---|
| Robust score chi2 | 59.16 [0.0000] | --- | --- | --- | --- | --- |
| Robust regression F | 181.32 [0.0000] | --- | --- | --- | --- | --- |
| Endogenous $R^2$ | 0.7630 [0.0000] | --- | --- | --- | --- | --- |
| Score chi2 | 27.202 [0.0000] | --- | --- | --- | --- | --- |

**Notes:** Q indicates quantiles. a, and b indicate $p < 0.05$, and $p < 0.01$, respectively. Employed for each estimator are exogenous regressors: lnFdı, endogenous regressor; lnGdp, excluded instruments; lnPop lnEu. We also used a robust version of the 2SLS, the VCE version, which confirmed the 2SLS results.

Table 4 presents the estimated coefficients. The SIV-QR findings show that for lnGdp, coefficients are intervals of 0.96 and 1.19 and positive and significant in all quantiles. Therefore, per capita income (lnGdp) leads to an increase in lnCo2. On the other hand, the lnFdı coefficients are -0.09 and -0.04, which is significant in the last three quantiles, indicating that lnFdı leads to a decrease effect in lnCo2. We used the 2SLS method to check the robustness of the SIV-QR findings.

In addition, the 2SLS results confirmed the SIV-QR findings. We also run several tests to determine the accuracy of our endogenous variables in the model. All the tests yielded similar results, so lnGdp is endogenous to the model and is instrumented with lneu and lnpop.

### 4.1. Robustness Check

We employed the simultaneous-quantile regression (sqr) method for the robustness check of the SIV-QR findings. Simultaneous quantile regression can report standard errors to obtain an estimate of the VCE via bootstrapping; the VCE includes between-quantile blocks. Thus, we can test the confidence intervals by comparing the coefficients with different quantiles.

**Table 5.** Sqr Results

| **Dependent Variable: lnCo2** | **Sqr** | | | | |
|---|---|---|---|---|---|
| | **Q10** | **Q25** | **Q50** | **Q75** | **Q90** |
| lnGdp | .29[a] | .52[b] | 1.01[a] | .97[a] | .84[a] |
| lnFdı | .09[b] | -.19 | -.06 | -.10[b] | -.11[a] |
| Constant | -2.05[a] | -3.6[b] | -6.8[a] | -6.28[a] | -4.97[a] |
| Pseudo $R^2$ | 0.3634 | .2207 | 0.4432 | 0.3934 | 0.3492 |

**Notes:** Q indicates quantiles. a, and b indicate $p < 0.05$, and $p < 0.01$, respectively. Simultaneous quantile regression bootstrap is 100.

Table 5 presents the findings of the Sqr method, which has no endogeneity or exogeneity. The Sqr findings show that for lnGdp, coefficients are intervals of 0.29 and 1.01, positive and significant in all quantiles. On the other hand, the lnFdı coefficient is 0.09 on low quantile. Sqr findings show that FDI has a decreasing effect (negative) on low quantile unlike SIV-QR findings. On the contrary, FDI has a decreasing effect of the high quantiles of .75$^{th}$ and .90$^{th}$ on Co2.

Finally, we examine the FDI and Co2 relationships with the help of graphics. The plots in Figure 2 show the median regression with bootstrap standard errors (bsqreg). This implies that bsqreg is equivalent to Sqr with one quantile.

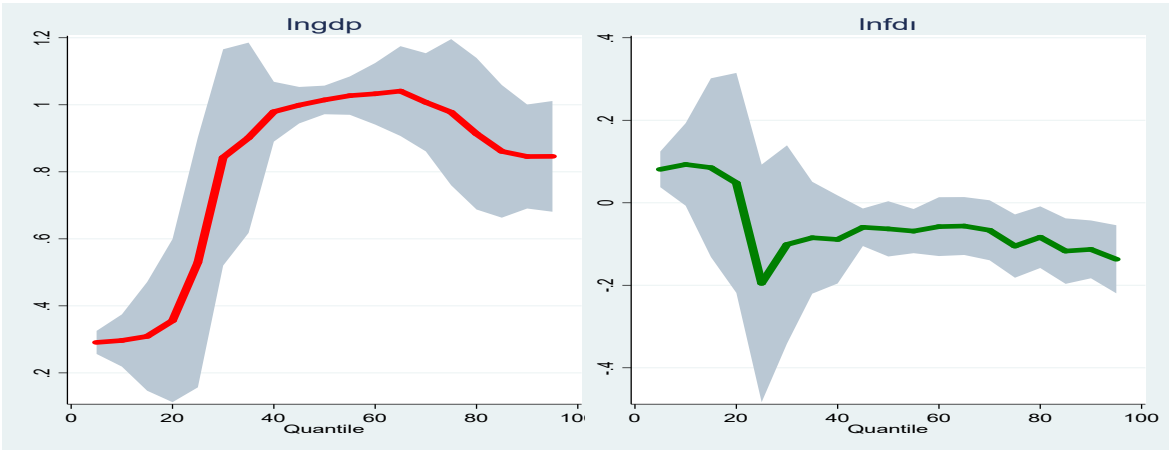


**Figure 2**: Bootstrap Standard Errors Plots

Figure 2 displays graphs of the quantiles, with the x-axis ordered from 0. to 100, and the vertical axes representing the effect variables. The red line indicates a positive coefficient for lnGdp across all quantiles, while the green line lnFdı has a negative effect on the low quantile, but turns positive on the 25th quantile. The first effect validates the pollution haven hypothesis for our sample in the low quantiles and the second effect implies the technological effect that reduces pollution in the high quantile.

### 4.2. Discussion

In this study, we use three estimators. Two of these were SIV-QR and IV-2SLS. SIV-QR neatly captures breaks in time and helps us consider interiority. In the model we created to investigate the effects of FDI on CO2 emissions, per capita GDP was used as an endogenous variable and population and electricity consumption were used as instrumental data. Because our two main estimators, SIV-QR and IV-2SLS, use population and electricity consumption as instrumental data, their coefficients have not been calculated. In this regard, we can only compare the findings on FDI and per capita GDP with those in the literature.

From the GDP perspective; Bakhsh et al. (2017) investigated the effects of GDP on Co2 for Pakistan using 3SLS in terms of technical and composition effects. Their findings showed that GDP has an increasing effect on Co2 and reductions in GDP have a very limited effect on Co2. Behera & Dash's (2017) findings on the positive effects of GDP on high and middle-income countries, and Khan & Öztürk's (2020) findings on the effects of GDP for 17 Asian Countries are consistent with our findings. On the other hand, the findings of Chang and Li (2018), Koçak & Şarkgüneşi (2018), Keho (2015), and Tang &Tan (2015), among the studies examining relationships in the context of the EKC model, show an inverse U-shaped relationship. Among these, only Chang and Li (2018) used a nonlinear method. Our findings, which are the bootstrap simultaneous quantile regressions, show that GDP draws an inverse U-shaped curve, but no coefficient that changes over time is negative. Accordingly, differing from the others, our findings show that the polluting effects of GDP decrease only in higher quantiles. In addition to, Mohsin et al. (2022) prove that short- and long-run effects differ regarding the GDP effect for developing countries.

From the FDI perspective; Bakhsh et al. (2017), Behera & Dash (2017), Sapkota & Bastola (2017), Chang & Li (2018), Koçak & Şarkgüneşi (2018), and Salahuddin et al. (2018), Muhammad & Khan (2019), Esendoh et al. (2020), Khan & Öztürk (2020), Aslan et al. (2021)'s findings showed the enhancing effects of FDI on Co2 unlike to ours. Essondoh et al. (2020) found that GDP and FDI an increased effect on Co2 for low-income countries and Balsalobre-Lorente et al. (2022) showed that FDI has increase effect on Co2. Their ECK findings are inverse U shape relationship with GDP and GDP square and Co2. However, the effects of FDI can change over time.

Our study differs from these studies in terms of the methods used. Most of these studies used methods that could capture only the long-term or both the short- and long-term effects of FDI on Co2. However, our estimator is a quantile. Standard regressions which are the methods used in the studies above are often used to estimate the mean or expected values. However, quantile regression focuses on predicting certain percentages (quantiles) of a target variable. That is, the regression coefficients are calculated by focusing on the distribution in certain percentiles. This allowed us to understand the general trend as well as the changes in certain segments by examining the effects of the variables in the dataset at different percentages.

On the other hand, our findings are consistent with the findings of Keho (2015), Tang & Tan (2015), Behera & Dash (2017). Behera & Dash (2017) divide countries into income levels. Awan (2022) investigated the effects of FDI for ten emerging countries with panel moment quantile and the findings are compatible with ours in terms of FDI, but the author may have misinterpreted the plot of moment quantile for GDP. This is because all the moment quantile coefficients for GDP are positive. Although the findings are consistent with the general consensus for developing countries, the effects vary over time or effects that vary in different quantiles. The reason for this may be that some study models used are nonlinear or quantile estimators based on the EKC, which may affect the findings. Second, different findings may depend on the choice of variables, because there is no consistency in the literature regarding the representation of FDI.

## 5. CONCLUSION

While increasing environmental awareness in developed countries affects the location or amount of production geographically, the relatively weak environmental policies of developing countries attract pollution from other countries as well as domestically produced pollution. The realization of this process with foreign direct investment flows is expressed by the pollution haven hypothesis.

The pollution haven hypothesis refers to the evasion of environmental standards by shifting production activities to countries subject to less regulation and control due to the increase in the costs of economic activities in countries with stricter environmental regulations. Costs of clean production, in particular, force the production forces of the EU and developed countries to migrate in the context of net zero greenhouse gas emission targets in the fight against the climate crisis. The risk of the industry moving to less-regulated regions is possible due to strict environmental regulations in developed countries. Developing countries offer good opportunities for substitution with low environmental costs but high or at least productivity in the region of capital migration. For developing countries, this process means that foreign exchange inflows, employment increases, and technology transfers may be seen as opportunities, but their returns may not always be as expected.

This study investigated the effects of foreign direct investment flows and economic growth on carbon emissions based on 1992-2020 annual data for the five emerging economies (Brazil, Russia, India, China, and South Africa (BRICS)). Population density and electricity consumption were used as the instrumental variables in the novel panel smooth quantile regression. As a research method, we used the instrumental variables smooth quantile regression method, which is a novel method in panel econometrics. Our findings indicate the negative effects of FDI flows on Co2 in low quantiles and the positive effects of economic growth. We robust these findings using the instrumental variables of the two-stage least squares estimation, and confirm that our choice of operational variables is correct.

We cross-checked our findings using a different quantile estimator that does not consider exogeneity. Simultaneous quantile regression findings show that FDI has an increased effect in low quantiles, but this effect turns positive, similar to the instrumental smooth quantile findings. These findings show that in BRICS countries, the pollution haven hypothesis is valid in the low quantile. In addition, the findings imply that possibility emphasizes the reducing effects of investments in technology on pollution. In other words, technological effect in which direct foreign investment flows reduce pollution in the high quantile.

Based on our findings, we make two recommendations: one for policymakers and one for researchers. Policymakers should focus on long-term environmental policies rather than short-term growth plans. Second, our simultaneous quantile regression plot findings show a threshold value. Researchers may focus on this threshold value using threshold methods that consider nonparametric and nonlinear relationships between the variables.

Developing countries with direct foreign investment inflows must pay attention to the quality of foreign direct investment to increase their development by bringing in foreign investment. High-technology investments may have positive effects on development and the environment. However, it should be noted that the climate crisis is not a regional but a global phenomenon, not only for those who receive capital migration but also for those who provide capital migration. Finally, border carbon trading, a market-based approach to combating climate crises, may be strengthened and expanded to reduce the effectiveness of the pollution haven hypothesis. Achieving the 2030 global warming target and 2050 net zero greenhouse gas emission target is extremely important in the fight against climate crises.

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**AUTHORS' CONTRIBUTIONS**

Writing - original draft, Conceptualization, Data curation, Formal analysis, Methodology, Software, Investigation, Visualization – **İÖ,** Writing - original draft, Writing -review & editing, Investigation, Visualization - **SB**.

**REFERENCES**

Abdilabekov, S., & Kaleci, F. (2020). Türkiye ve Şangay beşlisinde makroekonomik kırılganlığın karşılaştırmalı analizi. *Necmettin Erbakan Üniversitesi Siyasal Bilgiler Fakültesi Dergisi*, 2(1), 48-58.

Adom, P. K., & Amuakwa-Mensah, F. (2016). What drives the energy saving role of fdı and industrialization in East Africa? *Renewable and Sustainable Energy Reviews*, 65, 925-942.

Ali, W., Abdullah, A., & Azam, M. (2017). Re-visiting the environmental kuznets curve hypothesis for Malaysia: fresh evidence from ARDL bounds testing approach*, Renewable and Sustainable Energy Reviews*, 77, 990-1000.

Aslan, A., Altinoz, B., & Atay Polat, M. (2021). The nexus among climate change, economic growth, foreign direct investments, and financial development: new evidence from N-11 countries, *Environmental Progress and Sustainable Energy*, 40, 13585.

Awan, A., Abbasi, K. R., Rej, S., Bandyopadhyay, A., & Lv, K. (2022). The impact of renewable energy, internet use and foreign direct investment on carbon dioxide emissions: a method of moments quantile analysis. *Renewable Energy*, 189, 454-466.

Balsalobre-Lorente, D., Driha, O. M., Halkos, G., & Mishra, S. (2022). Influence of growth and urbanization on co2 emissions: the moderating effect of foreign direct investment on energy use in BRICS. *Sustainable Development*, 30(1), 227-240.

Bakhsh, K., Rose, S., Ali, M. F., Ahmad, N., & Shahbaz, M. (2017). Economic growth, co2 emissions, renewable waste and fdi relation in Pakistan: new evidences from 3sls. *Journal of Environmental Management*, 196, 627-632.

Behera, S. R., & Dash, D. P. (2017). The effect of urbanization, energy consumption, and foreign direct investment on the carbon dioxide emission in the SSEA (South and Southeast Asian) region. *Renewable and Sustainable Energy Reviews*, 70, 96-106.

Boly, M., Combes, J. L., Menuet, M., Minea, A., Motel, P. C., & Villieu, P. (2022). Can public debt mitigate environmental debt? theory and empirical evidence. *Energy* Economics, 111, 105895.

Chang, S. C., & Li, M. H. (2019). Impacts of foreign direct investment and economic development on carbon dioxide emissions across different population regimes. *Environmental and Resource Economics,* 72(2), 583-607.

Chatterjee, M., & Naka, I. (2022). Twenty years of BRICS: political and economic transformations through the lens of land. *Oxford Development Studies*, 50 (1), 2-13.

Cole, M. A. (2004). Trade, the pollution haven hypothesis and the environmental kuznets curve: examining the linkages. *Ecological Economics*, 48, 71-81.

Çetin, M., Sarıgül, S. S., Topcu, B. A., Alvarado, R., & Karataser, B. (2023). Does globalization mitigate environmental degradation in selected Emerging economies? assessment of the role of financial development, economic growth, renewable energy consumption and urbanization. *Environmental Science and Pollution Research*, 30(45), 100340-100359.

Dhrifi, A., Jaziri, R., & Alnahdi, S. (2020). Does foreign direct investment and environmental degradation matter for poverty? evidence from developing countries. *Structural Change and Economic Dynamics*, 52, 13-21.

Dean, J. M., Lovely, M. E., & Wang, H. (2009). Are foreign investors attracted to weak environmental regulations? evaluating the evidence from China. *Journal of Development Economics*, 90, 1-13.

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.

French, H. (1998) Capital flows and the environment. *Foreign Policy in Focus*, https://fpif.org/capital_flows_and_the_environment/ [Retrieved date: 04.24.2023].

Haug, A. A., & Ucal, M. (2019). The role of trade and fdi for co2 emissions in Turkey: nonlinear relationships. *Energy Economics*, 81, 297-307.

Kander, A., & Lindmark, M. (2006). Foreign trade and declining pollution in Sweden: a decomposition analysis of long-term structural and technological effects. *Energy Policy,* 34, 1590-1599.

Kaplan, D. M., & Sun, Y. (2017). Smoothed estimating equations for instrumental variables quantile regression. *Econometric Theory*, 33, 105-157.

Keho, Y. (2015). Is foreign direct investment good or bad for the environment? times series evidence from ECOWAS countries. *Economics Bulletin*, 35(3), 1916-1927.

Khan, M. A., & Ozturk, I. (2020). Examining foreign direct investment and environmental pollution linkage in Asia. *Environmental Science and Pollution Research*, 27, 7244-7255.

Koç, Ş., & Özcan, G. (2023). Endüstri 4.0'ın ekonomik büyüme üzerindeki etkisinin incelenmesi: G7 ülkeleri için panel veri analizi. *Necmettin Erbakan Üniversitesi Siyasal Bilgiler Fakültesi Dergisi*, 5(1), 1-16.

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, 790-804.

Kong, Z., Du, J., Kong, Y., & Cui, X. (2024). Financial development, environmental regulation, and corporate green technology innovation: evidence from Chinese listed companies. *Finance Research Letters*, 105122.

Li, M., Du, W., & Wang, Z. (2023). Export globalization and pollution localization: multivariate heterogeneous data based on Chinese enterprises. *Energy Reports*, 9, 472–483.

Liu, P., Rahman, Z. U., Jóźwik, B., & Doğan, M. (2024). Determining the environmental effect of Chinese fdi on the Belt and Road countries co2. *Environmental Sciences Europe*, 36(48), 1-12.

Marques, A. C., & Caetano, R. (2020). The impact of foreign direct investment on emission reduction targets: evidence from high-and middle-income countries. *Structural Change and Economic Dynamics*, 55, 107-118.

Mohsin, M., Naseem, S., Sarfraz, M., & Azam, T. (2022). Assessing the effects of fuel energy consumption, foreign direct investment and gdp on co2 emission: new data science evidence from Europe & Central Asia. *Fuel*, 314, 123098.

Muhammad, B., & Khan, S. (2019). Effect of bilateral fdi, energy consumption, co2 emission and capital on economic growth of Asia countries. *Energy Reports*, 5, 1305-1315.

Muhammad, B. (2019). Energy consumption, co2 emissions and economic growth in developed, emerging and middle East and North Africa countries. *Energy*, 179, 232-245.

Nasir, I. M., Buluş, A., & Gömleksiz, M. (2022). Trade openness and fdi from Turkey: does it matter for economic growth in African countries? *Medeniyet ve Toplum Dergisi*, 6(1), 21-37.

Oanh, T. T. K. (2024). Digital financial inclusion in the context of financial development: environmental destruction or the driving force for technological advancement. *Borsa Istanbul Review,* 24 (2), 292-303.

O' Neill, J. (2001). Building better global economic BRICS. *Global Economics Paper Series (No. 66)*, 30th November 2001, Goldman Sachs Global Research Centers.

Omri, A., Nguyen, D. K., & Rault, C. (2014). Causal interactions between co2 emissions, fdi, and economic growth: evidence from dynamic simultaneous-equation models. *Economic Modelling*, 42, 382-389.

OWD, Our World in Data (2023a). https://ourworldindata.org/Co2-emissions. [Retrieved date: 04.20.2023].

OWD, Our World in Data (2023b). https://ourworldindata.org/energy. [Retrieved date: 04.20.2023].

Pao, H. T., & Tsai, C. M. (2011). Multivariate Granger causality between co2 emissions, energy consumption, fdi (foreign direct investment) and gdp (gross domestic product): evidence from a panel of BRIC (Brazil, Russian Federation, India, and China) countries. *Energy*, 36, 685-693.

Peng, H., Tan, X., Li, Y., & Hu, L. (2016). Economic growth, foreign direct investment and co2 emissions in China: a panel Granger causality analysis. *Sustainability*, 8(233),1-13.

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(2), 2002-2010.

Sapkota, P., & Bastola, U. (2017). Foreign direct investment, income, and environmental pollution in developing countries: panel data analysis of Latin America. *Energy Economics*, 64, 206-212.

Shahbaz, M., Balsalobre-Lorente, D., & Sinha, A. (2019). Foreign direct investment- co2 emissions nexus in Middle East and North African countries: importance of biomass energy consumption. *Journal of Cleaner Production*, 217, 603-614.

Shahbaz, M., Dogan, M., Akkus, H. T., & Gursoy, S. (2023). The effect of financial development and economic growth on ecological footprint: evidence from top 10 emitter countries. *Environmental Science and Pollution Research,* 30, 73518-73533.

Tang, C. F., & Tan, B. W. (2015). The impact of energy consumption, income and foreign direct investment on carbon dioxide emissions in Vietnam. *Energy*, 79, 447-454.

Topcu, B. A. (2016). The relationship between foreign direct investment and industrialization in developing countries: panel data analysis. *The Journal of Academic Social Science*, 4(35), 390-400.

Topcu, B. A. (2022). Türkiye'de sürdürülebilir çevre: finansal gelişme, yenilenebilir ve yenilenemeyen enerji tüketimi ve doğal kaynak gelirlerinin rolü. *The Journal of Academic Social Science*, 129(129), 43-60.

Voumik, L. C., & Ridwan, M. (2023). Impact of fdi, industrialization, and education on the environment in Argentina: ardl approach. *Heliyon*, 9(1), e12872.

WDI, Word development indicators (2023). https://databank.worldbank.org/reports.aspx?source=World-Development-Indicators#. [Retrieved date: 04.20.2023].

Xiong, J., & Xu, D. (2021). Relationship between energy consumption, economic growth and environmental pollution in China. *Environmental Research*, 194, 110718.

Xie, Q., Wang, X., & Cong, X. (2020). How does foreign direct investment affect co2 emissions in emerging countries? new findings from a nonlinear panel analysis. *Journal of Cleaner Production*, 249, 119422.