Do Green Investments Improve Air Quality? Evidence for Developed and Developing European Countries

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Abstract

A large part of the energy supply required for production in the world consists of non-renewable energy sources such as coal, oil, and natural gas. Due to the serious increases in these energy sources in the world, countries facing the threat of climate change and increasing global warming have had to direct their energy policies to reduce carbon emissions. In this respect, promoting and increasing renewable energy, known as clean, green energy, and environmentally friendly, is an important factor in reducing carbon emissions in nature. In this context, in this study, the effect of green investment on air quality for two country groups was examined. As a result of the analysis, it was determined that the results differed both for the country groups and for the short and long term.

1. Introduction

Sustainable development requires increasing environmental quality in all countries (Baloch et al., 2021). While many factors contribute to environmental quality, the rate of carbon emissions in the atmosphere is one of the most significant determinants. Carbon dioxide emissions per capita increased from 3.1 tons in 1960 to 4.4 tons by 2018. According to the World Bank, China, the USA, EU countries, India, and Russia contribute the most to the pollution of the atmosphere. Due to this rapid rise in carbon emissions, there have been doubts about whether countries will be able to achieve their sustainable development goals. Murshed and Tanha (2021) point out that both the increase in carbon emissions and the uncertainty around sustainable development goals have led to global policies aimed at reducing carbon emissions. In these circumstances, setting a development goal based on green resources is one of the most critical policies. As a result of green investments, countries and companies can channel financial resources into areas that do not pollute the environment (Li and Gan 2021).

Investing in environmentally friendly projects such as those aimed at conserving natural resources, generating and improving renewable energy sources, ensuring the protection of clean air and water, and using renewable energy sources as a source of energy have been defined as green investments by Chen and Ma (2021). To put it another way, it can be defined as investments based on social and environmental norms, and that is intended to benefit both. As part of this context, some researchers have conducted research to determine whether green investments are likely to play a role in reducing carbon emissions in the future (Ren et al., 2022). Several studies have provided evidence in support of this hypothesis, including Lindenberg (2014), Karasek and Pavlica (2016), Krushelnytska (2019), Nassiry (2019), and Heine et al. (2019). Meanwhile, Zahan and Chuanmin (2021) showed that green investments have the potential to minimize carbon emissions in the short term, but they are likely to increase carbon emissions in the long term. Overall, it is expected that green investments will contribute to the improvement of air quality because they will conserve energy and lower emissions of carbon dioxide.

Evidently, green investments are strategically promoting environmental regulative standards (Eyraud et al. 2013; Karásek and Pavlica 2016), while Xu et al., 2017; Wan and Sheng, 2022; Chen and Ma, 2021; Shen et al., 2021; Musibau et al., 2021; Ren et al., 2020 argued that green investments are targeted toward reducing fossil fuel consumption and carbon emissions. Although, Zahan and Shuai (2021), Hammoudeh et al. (2020), and Charfeddine and Kahia (2019) argued that there is no relationship between green investment and environmental quality. However, there is credible evidence in the previous studies that green investment could promote air quality. But most of these studies use capital expenditure on the environment as a proxy for green investment. We argued that capital investment in the environment only forms an aspect of green investments. Hence, should not be used to generalize as an indicator for green investment. Given this fact, we examine the effects of investments made in the transition to green energy for two groups of European countries: developed European countries and developing European countries using public investment in renewable energy.

Our study makes significant contributions to literature and practice in several ways. First, this study enriches the literature on green investment by focusing on public investment in renewable energy. Previous studies use capital expenditure on the environment as a proxy green investment, which merely explains some portion of green investment. Second, to the best of our knowledge, this is the first study that compares developed versus developing European economies when it comes to green investment and air quality. Third, we contribute to the literature by applying a more robust econometric approach.

The rest of the paper is as follows. We review the literature in Section 2. The research methods are presented in Section 3. Section 4 contains the analyses and discussions. The paper concludes in Section 5

2. Literature Reviews

2.1. Green Investment and Air Quality

Most researchers consider green investments as a type of investment that raises environmental standards and considers social responsibility (Eyraud et al. 2013; Karásek and Pavlica 2016). Xu et al. (2017), on the other hand, for an investment to be considered a green investment, it must reduce the proportion of fossil fuels in total energy consumption. In this context, green investments will support the transition to renewable energy, and this will help reduce the rate of carbon released to the environment. When the literature is examined; Wan and Sheng (2022), Chen and Ma (2021), Shen et al. (2021), Musibau et al. (2021), and Ren et al. (2020) have determined that green investments have a significant contribution to reducing carbon emissions. Despite that; Zahan and Shuai (2021), Hammoudeh et al. (2020), and Charfeddine and Kahia (2019), on the other hand, could not detect a significant relationship between green finance investments and carbon emissions. Nevertheless, the hypothesis regarding the assumption that green investments will have a positive effect on carbon emissions is set up as follows;

H: There is a statistically positive relationship between green investments and air quality.

2.2. Economic Growth and Air Quality

The relationship between carbon emissions and economic growth can sometimes be confusing. The Environmental Kuznets Curve (EKC) hypothesis explains this confusion as follows: The curve showing the carbon emission on the graph moves up until it reaches a certain income threshold, while it moves down after the threshold is crossed, forming an inverted "u" shaped graph (Arouri et al.,2012). In other words, while increasing income increases carbon emissions in the short term, it decreases them in the long term. The relationship between economic growth and carbon emissions has been studied extensively, especially in the last 40 years. However, the results of empirical studies have been controversial, showing contradictory effects. For this reason, a definite policy cannot be suggested for its implementation between countries (Acaravcı and Öztürk, 2010). When the relevant literature is examined; Wang et al. (2012), Wang et al. (2013), Paul and Bhattacharya (2004), Elif et al. (2011), Acaravcı and Öztürk (2010), Al-mulali et al. (2013) have found that economic growth increases carbon emissions. Heidari et al. (2015), Narayan and Pop (2012), and Jaunky (2010) found that while economic growth increases carbon emissions in the short run, as the EKC hypothesis suggests, it decreases it in the long run. Despite that; Kalimeris et al. (2014), Bruns et al (2014), Hossain (2011), and Soytaş et al. (2009) concluded that there is no clear relationship between economic growth and carbon emissions.

2.3. Urbanization and Air Quality

Considering that carbon emissions have a positive relationship with energy consumption (Ramzan et al. 2021), it can be said that urbanization will increase energy consumption and energy consumption will increase CO2 emissions. In other words, as urbanization increases, more energy will be consumed and carbon emissions will increase accordingly. In this case, it can be expected that there will be a positive relationship between urbanization and carbon emissions. Reviewing the literature, Zambrano-Monserrate et al. (2018), Nasreen et al. (2017), Rahman (2017), Alama et al. (2016), Karakaş (2016), Bozkurt and Okumuş (2015), Ohlan (2015), Onafowora and Owoye (2014), Prose and Rehman (2011), etc. They concluded that there is a positive relationship between these two variables. In this context, it is expected that urbanization will increase carbon emissions and this situation will decrease air quality.

2.4. Energy consumption and Air Quality

In parallel with the progress of modern industrial civilization and the excessive increase in production, energy consumption has increased considerably. This situation has brought about the use of energy sources such as fossil fuels that are harmful to the environment and increase CO2 emissions. This situation emerges as a major obstacle in achieving the goal of a sustainable world. Based on the fact that energy consumption increases CO2 emissions, the use of renewable energy sources and ensuring sustainability have become the common goal of countries (Lia et al. 2011). When the literature is examined for the relationship between energy consumption and CO2 emission; According to Ramzan et al. (2021), Adedoin et al. (2021), and Mahalik et al. (2021). Cetin and Yuksel (2018), Sun et al. (2017), Bautabba (2014), Shahbaz et al. (2013), Hamit-Haggar (2012), and Pao et al. (2011) found in their studies that energy consumption increases carbon emissions. In contrast, Adebayi et al. (2022), Kırıkkale and Adebayo (2021), Ding et al. (2021), Ibrahim and Ajide (2021), Yuping et al. (2021), Umar et al. (2020) found a negative relationship between renewable energy use and CO_2 emissions in their studies. In this case, if an evaluation is made by looking at the literature, it is seen that the use of non-renewable energy increases carbon emissions, while the use of renewable energy sources reduces carbon emissions. In this context, it is expected that the increase in energy consumption did not decrease the air quality.

2.5. Trade Openness and Air Quality

Since the beginning of the 2000s, whether there is a relationship between trade openness and environmental pollution has become a debated and researched the issue. This discussion emerged after the positive relationship between trade openness and economic growth was understood (Shahbaz et al. 2017). The biggest factor in the impact of trade openness on the environment is the hypothesis called a pollution haven. In short, the pollution haven hypothesis is that large or high-polluting companies invest in countries where environmental regulations are not strictly enforced and make large-scale production there, resulting in huge CO_2 emissions (Dauda et al., 2021). When the literature is reviewed, Sarkodie and Strezov (2019), Liu et al. (2018), and Chai et al. (2018) determined the correctness of the pollution haven hypothesis in their studies and showed that countries with trade openness increase CO_2 emissions. Besides, Chen et al (2019), Balsalobre-Lorente et al. (2018), and Shahbaz et al. (2017) have shown in their studies that trade openness negatively affects the environment. According to Essandoh et al (2020), trade openness reduces CO_2 emissions in developed countries while increasing them in less developed countries. According to Wang and Zang (2021), trade openness reduces carbon emissions in high-income countries. Kim et al. According to (2019), while southern trade reduces carbon emissions, northern trade increases. Wang and Wang (2021) found that trade openness reduces carbon emissions in high-income and low-middle-income groups, but increases it in the upper-middle-income group. In contrast, Kearsley and Riddel (2010), Ang (2007), and Soytas et al. (2007) could not conclude whether trade openness has an environmental impact or not.

3. Data And Methodology

3.1. Variables and data descriptions

This study is primarily concerned with the time evolution of green investment. The researchers used several proxy measures to represent green investment growth over time. Patent applications, energy-related R&D expenditures, and the consumption of renewable energy are considered among them. In this study,yeşil yatırımı temsilen Luo et.al (2021) ve Desalegn et al.(2022 takip edilerek public investment in renewable energy kullanılmıştır. Ilgili data ise International Renewable Energy Agency (IRENA)'derlenmiştir.

As an air quality indicator, Tan et. all (2022), and Canh et. all (2021) were followed and carbon emissions were used. In this context, while the increase in carbon quality decreases the air quality, the decrease in the carbon level shows that the air quality increases. Bu veri ise WDİ (2022)'den alınmıştır.

Additionally to the analysis of green investment and carbon dioxide emissions, this study also examines the relationship between air quality and economic growth, population density, overall energy consumption, and trade openness, all of which are commonly used control variables in studies related to green investment and air quality. Gross domestic product (GDP) per capita is calculated by dividing the gross domestic product by the midyear population. A country's gross domestic product consists of all the gross value added by all the industries in the economy plus any product taxes or subsidies not included in the value of the products. Urban population density (Urban) is calculated as the ratio of urban to the total population. According to national statistical offices, urban populations are defined as people living in urban areas. Consumption of energy (EnergyCons) is defined as the use of primary energy before it is transformed into other end-use fuels. Furthermore, trade openness (TradeOp) represents the value of international trade in the form of goods and services that are provided to or received from outside the country divided by the number of people living in that country. The dataset consists of all variables in annual frequency retrieved from the World Development Indicators database.

Our sample includes 31 European economies grouped into the EU-15 and EU-others sub-samples. EU-15 countries are categorized in the United Nations World Economic Situation and Prospect Report 2018. The EU-15 sample includes 15 developed European countries (Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom), all of which are members of the European Union except the United Kingdom and the EU-others sample consists of 16 European countries (Bulgaria, Croatia, Cyprus, Czech Republic, Estonia, Hungary, Iceland, Latvia, Lithuania, Malta, Norway, Poland, Romania, Slovak Republic, Slovenia, Switzerland), both European Union members and non-members, excluding EU-15 countries. Two European subsamples are selected because this region's economies are becoming increasingly important in the global economy and there are few studies about the difference between developed and developing countries in Europe. Our sample spans ten years between 2009 and 2018. Table 1 presents the definitions of variables, and Table 2 presents descriptive statistics for the variables. Table 3 presents the correlation matrix for the variables.

Table 1
Definitions of Variables

Variable	Definition	Sources
AirQuality	CO2 emissions (metric tons per capita)	WDİ (2022)
GDP	GDP per capita (constant 2015 US$)	WDİ (2022)
Green İnvestment	Public investment in renewable energy	IRENA(2022)
TradeOp	(Exports + Import (current US$)) / (Population)	WDİ (2022)
EnergyCons	Energy use (kg of oil equivalent per capita)	WDİ (2022)
Urban	Urban population (% of the total population)	WDİ (2022)

Table 2
Descriptive Statistics

	Mean	Std.Dev.	Min	Max	Obs
Panel A: EU-15 countries					
AirQuality	7.732079	3.354091	3.538009	21.81662	150
GDP	43604.6	20060.44	17796.26	108351.5	150
Green İnvestment	29.1356	13.32854	3.3778	52.8915	150
TradeOp	59704.46	82196.05	10182.14	379095.2	150
EnergyCons	3934.7	1516.48	2034.513	8329.479	105
Urban	78.7984	11.15445	57.115	98.001	150
Panel B: EU-other countries					
AirQuality	6.258547	2.447485	2.964713	14.55997	160
GDP	25477.06	22733.43	6288.677	87980.67	160
Green İnvestment	15.22785	18.52468	0.2564	78.2135	160
TradeOp	30107.01	23511.77	4371.703	100801.1	160
EnergyCons	2953.842	3838.544	1591.668	18178.14	105
Urban	69.21896	12.2598	52.433	94.612	160

When Table 2 is examined, it is seen that the average carbon emission (air quality) in EU-15 countries is higher than in EU-other countries, while GDP and green investments are almost twice that of EU-other countries. Similarly, it is seen that trade openness is quite high in EU-15 countries compared to other EU countries, and energy consumption and urbanization figures are close to each other. The highest green investments detected in EU-other countries originate from Norway and Switzerland.

When the results of Table 3 are examined, a statistically significant negative correlation was found between air quality and green investments in EU-15 countries, while this relationship was found to be statistically insignificant in other EU countries. While a positive statistically significant correlation was found between GDP, trade openness, energy consumption, and urbanization in EU-15 countries, these relationships were found to be statistically insignificant in EU-other countries.

Table 3
Correlation Matrix

	AirQuality	GDP	Green İnvestmnet	TradeOp	EnergyCons
Panel A: EU-15 countries					
GDP	0.7805***	1			
Green İnvestment	-0.3809***	-0.0969	1		
TradeOp	0.8371***	0.9224***	-0.2499***	1	
EnergyCons	0.7314***	0.7602***	0.0886	0.6615***	1
Urban	0.3048***	0.3357***	-0.1236	0.2560***	0.5548***
Panel B: EU-other countries					
GDP	0.0395	1			
Green İnvestment	-0.0377	0.5071***	1		
TradeOp	-0.0163	0.8332***	0.1750**	1	
EnergyCons	0.1505	0.4363***	0.8133***	0.2606***	1
Urban	0.0614	0.4731***	0.3822***	0.5840***	0.5706***
*** p < 0.01, ** p < 0.05, * p < 0.1					

3.2. Methods and model specification

Baseline regression model

We specify our baseline model to be an OLS regression model:

$$lnAirQuality_{it} = \beta_0 + \beta_1 lnGreninvestment_{it} + \beta_2 lnGDP_{it} + \beta_3 lnUrban_{it} + \beta_4 lnTradeOp_{it} + \beta_5 lnEnergyCons_{it} + \beta_6 lnUrban_{it}{}^2 + \beta_7 lnGreeninvestment_{it}{}^2 + \varepsilon_{it} \quad (1)$$

Where β_0 measures the intercept and β_1 through β_7 measures the association of air quality with the explanatory variable of green investment and other control variables. The estimation is performed after all variables are transformed into natural logarithm from, denoted by ln. Without modifying the original data, the logarithmic transformation mitigates heteroscedasticity. The logarithmic transformation is also convenient because it eliminates the inconvenience posed by measurement errors.

3.3. Two-step dynamic System-GMM

Green investment and air quality has shown that pooled OLS estimations suffer from endogeneity problems and cannot be interpreted as causal relationships. For an independent (explanatory) variable to have a causal effect on the dependent variable, it must be exogenous. To put it another way, the explanatory variables should not be correlated with the error term. Robert and Whited (2013) identify reverse causality, measurement errors, and omitted variables as the key drivers of endogeneity.

Reverse causality is likely to be present in our baseline model. For example, the literature suggests that the $\beta_1$coefficient in Eq. 1 is expected to be negative. That is, innovations in green energy are expected to reduce carbon dioxide emissions. It is possible, however, that the relationship is bidirectional. Carbon dioxide emissions increasing to alarming levels may also urge regulators to create motivational advantages for producers to use less carbon dioxide producing methods, for instance, tax exemptions for green energy investments, which in turn will increase innovations in green energy. Therefore, reverse causality is an integral issue in our baseline model.

Additionally, our explanatory variables likely carry some correlations with the error term due to omitted variables and measurement errors. There is the possibility that the green investment variable might be correlated with some unobserved omitted variables that are determinants of the dependent variable. Therefore, consistency and efficiency of the baseline OLS regression model estimates might be undermined. Furthermore, the key variable of this study, green investment, is measured by renewable energy consumption, which may be inaccurately measured. As a result, the least squares estimates may be biased due to this attenuation. Similarly, the dependent variable of air quality might be incorrectly measured, which will highlight the possible endogeneity issue in the baseline OLS model. Although we use a reliable data source, the World Bank, a widely utilized data source in the literature, we cannot fully rule out the possibility of the existence of measurement error.

Therefore, we use the dynamic system-GMM estimator proposed first by Arellano and Bover (1995) and Blundell and Bond (1998). GMM models are commonly used to deal with endogeneity in the empirical literature, due to their consistency and efficiency. The model can be extended to account for endogeneity, resulting in unbiased results (Bond, Hoeffler, and Temple, 2001).

$$lnairquality_{it} = \beta_0 + \beta_1 lnGreeninvestment_{it} + \beta_2 lnGDP_{it} + \beta_3 lnUrban_{it} + \beta_4 lnTradeOp_{it} + \beta_5 lnEnergyCons_{it} + \beta_6 lnUrban_{it}{}^2 + \beta_7 lnGreeninvestment_{it}{}^2 + \beta_8 lnairqualitiy_{it-1} + \varepsilon_{it} \qquad (2)$$

The coefficients β_1 represents the short-term association between green investment and air quality. The coefficients β_2, β_3, β_4, and β_5 represent the short-time relationship between air quality concerning economic development (GDP), urbanization, trade openness, and energy consumption levels. Squared urbanization and squared green investment variables are also included in the model to account for inverted U-shape characteristics of the relationship of air qualitiy with population and green energy levels, measured with β_6 and β_7, respectively.

All the coefficient estimates in the equation give the short-term effects. If the short-term relationships are found significant, we additionally compute the long-term effects of the relationship between our regressors and air quality, which will also confirm the results of β_6 and β_7 in Eq. 2. Long-term coefficients are calculated as follows:

$$equal\beta_{i,long-term} = \beta_i/(1-\beta_8)$$

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3.4. Panel Causality Test

Emirmahmutoğlu and Köse's (2011) causality test is a test that takes into account the cross-section dependence that can be used even when the series is not stationary at the same level, that is, when some of the series are I(0) and some are I(1), and when a cointegration relationship cannot be determined between the variables (Emirmahmutoğlu and Kose, 2011). Results can be reported to this test both at the panel level and at the unit (country) level. A bivariate var model is set up as follows;

$$x_{i,t} = \mu_i^x + \sum_{j=1}^{k_i+d\max_i} A_{11,ij} x_{i,t-j} + \sum_{j=1}^{k_i+d\max_i} A_{12,ij} y_{i,t-j} + u_{i,t}^x \quad (4)$$

$$y_{i,t} = \mu_i^y + \sum_{i=1}^{k_i+d\max_i} A_{21,ij} x_{i,t-j} + \sum_{i=1}^{k_i+d\max_i} A_{22,ij} y_{i,t-j} + u_{i,t}^y \quad (5)$$

dmax represents the maximum level of integration for each in the system.

4. Empirical Results And Discussion

According to the OLS results in Table 4; It has been determined that the air quality in EU-15 countries was low in the early periods, but the air quality increased with increasing green investment levels. GMM short-term and long-term coefficients support the OLS model, and it has been determined that in the long run, green investments reduce carbon emissions and accordingly increase air quality. This finding is found in Wan and Sheng (2022), Chen and Ma (2021), and Shen et al. (2021), which supports the results of researchers such as.

According to the OLS model and short-term and long-term GMM results; In EU-other countries, it has been determined that green investments do not affect the air quality in general. This situation shows that EU-

15 countries give more importance to green investments compared to EU-other countries these findings support the results of the Charfeddine and Kahia (2019) study.

Across the models; It has been observed that the per capita income variable improves the air quality in EU-15 countries, while the per capita income variable does not affect the air quality in general in other EU countries. This situation can be explained by the fact that people in EU-other countries still do not reach a sufficient level of welfare. Kalimeris et al. (2014), Bruns et al. (2014), Hossain (2011), and Soytaş et al. (2009) concluded that there is no clear relationship between economic growth and carbon emissions and this relationship may vary from country to country.

It has been determined that the trade openness variable is insignificant in EU-15 countries and decreases the air quality in Eu-other countries. This finding shows that the "Pollution Paradise" hypothesis is valid for other EU countries. This finding supports the conclusion of the study by Essandoh et al (2020). It has been determined that energy consumption worsens the air quality in EU-15 countries, but does not affect the air quality in other EU countries. When we look at the EU-15 countries, it is expected that these countries are generally highly developed in industry, and accordingly, energy consumption is expected to be high in these countries. This situation causes an increase in carbon emissions and decreases air quality. In EU-other countries, less energy is consumed as the industry is relatively less developed. This situation supports fewer carbon emissions. This finding, by Cetin and Yuksel (2018), Sun et al. (2017), Bautabba (2014), Shahbaz et al. (2013), Hamit-Haggar (2012), and Pao et al. (2011) support their work

On the other hand, it is seen that the rate of urbanization worsens the air quality by increasing carbon emissions in the EU-15 countries, but after a certain level, the urbanization rate reduces the carbon level. The reason for this situation can be explained by the fact that EU-15 countries take measures due to increasing urbanization and this situation reduces the increasing carbon emissions. However, this shows that urbanization in EU-15 countries increases carbon emissions rapidly, which has led to a decrease in air quality. This finding, Zambrano-Monserrate et al. (2018), Nasreen et al. (2017), and Rahman (2017), support his work

Panel causality results are reported in Table 5. When Table 5 is examined, it is seen that the results obtained generally support the findings in Table 4. When the results are examined in detail, bidirectional causality has been detected between all variables except air quality and openness to the EU-15 countries. This finding shows that green investments, economic growth, urbanization, and energy consumption can be determinants of air quality. In addition, the findings obtained by Barut et al. (2022), Li et al. (2022), Kohler (2013), and Sun et al. (2019), supports the results of research such as. On the other hand, when the results for EU-other countries are examined; It has been determined that there is a causality between air quality, trade openness, and urbanization. This finding indicates that for EU-other countries, trade openness and urbanization can be important in determining air quality.

Table 4
OLS and System GMM estimation results

	Europe-15			Europe-others		
	OLS	Sys-GMM		OLS	Sys-GMM	
		short-term	long-term		short-term	long-term
$Lnairquality_{-1}$	–	0.567*	-0.387	–	0.748*	0.650
		(0.076)	(0.258)		(0.323)	(0.214)
lnGreeninvestment	0.422***	0.631**	-0.058**	0.191	0.114*	0.085
	(0.026)	(0.108)	(0.012)	(0.095)	(0.039)	(0.055)
lnGDP	-0.260**	-0.758**	-0.483**	0.024	0.088**	0.025
	(0.051)	(0.218)	(0.193)	(0.089)	(0.0001)	(0.145)
lnTradeOp	17.130	75.98	48.477	36.170***	5.672***	1.960*
	(10.41)	(54.2)	(36.847)	(7.248)	(0.860)	(0.385)
lnEnergyCons	0.263***	0.681**	0.434***	-0.018	0.092*	0.014
	(0.073)	(0.217)	(0.120)	(0.084)	(0.009)	(0.068)
Durban	0.615***	0.889*	0.567***	0.760***	0.134*	0.687**
	(0.106)	(0.306)	(0.136)	(0.073)	(0.028)	(0.108)
lnUrban^2	-2.047	-8.883*	-5.667*	-4.352***	0.983*	0.647**
	(1.212)	(3.973)	(3.127)	(-0.866)	(0.446)	(0.147)
lnGreeninvestment^2	-0.115**	-0.153*	-0.097**	-0.032	0.239*	0.145
	(0.042)	(0.066)	(0.044)	(0.019)	(0.065)	(0.210)
Year Dummies	–	Yes	–	–	Yes	–
Observations	105	90	–	105	89	–
Number of countries	15	15	–	16	16	–
Adj. R^2	0.699	–	–	0.552	–	–
AR(2)	–	0.764	–	–	0.174	–
Hansen J statistic	–	0.958	–	–	0.647	–

Note

*, **, and *** are statistical significance at the 10%, 5%, and 1% significance levels, respectively. Standard errors in parentheses are White heteroscedasticity-consistent standard errors. P-values are reported for AR(2) and Hansen statistics. Long-term System GMM coefficients are computed only for those significant in the short-term.

Table 5
Causality Test

	EU-15	**EU-Other**
	Panel Stat.	Panel Stat.
AirQuality to Green İnvestment	19.510***	6.210
Green İnvestment to AirQuality	15.265***	8.540
AirQuality to GDP	20.982***	8.210
GDP to AirQuality	13.125**	3.541
AirQuality to TradeOp	2.410	12.875**
TradeOp to AirQuality	4.248	15.320**
AirQuality to EnergyCons	9.210*	5.540
EnergyCons to AirQuality	25.650***	3.990
AirQuality to Urban	30.680***	20.785***
Urban to AirQuality	65.410***	45.490***

Note: *, **, and *** are statistical significance at the 10%, 5%, and 1% significance levels, respectively

5. Conclusion And Policy Implications

This paper analyzes empirically the impact of the time evolution of green investment air quality using panel data from 31 countries over the period of 2009–2018. An initial regression model is employed as well as a two-step dynamic system-GMM model based on Arellano and Bover (1995) and Blundell and Bond (1998). This sample is divided into two subsamples based on the differences in economic development levels: the EU-15 and the EU-others.

We use renewable energy consumption as a proxy for green investment in this paper. It is assumed that an increase in green energy investment leads to an increase in green energy production and therefore consumption. We propose that green energy investment reduces fossil fuel consumption in total energy consumption. In turn, this will reduce the amount of CO_2 released into the atmosphere. To measure the effect of green energy investment on CO_2 emissions, a number of variables have been used as controls. These variables include economic growth, urbanization, energy consumption, and trade openness.

EU-15 ülkelerinde yeşil yatırımların oldukça önem kazandığı modellerde görülmektedir. Her nekadar başlangıç aşamasında yeşil yatırımlar hava kalitesini iyileştimesede ilerleyen zamanlarda yeşil yatırımlarınrın karbon salınımını azaltarak hava kalitesinin iyileşmesinde ciddi katkı sağladığı görülmektedir. Ancak EU-diğer ülkleri için bu durumun geçerli olmadığı tespit edilmiştir.Bu durumunun nedeninin ise EU-diğer ülklerinin yeşil yatırımlara yeteri kadar önem vermemesi olduğu düşünülmektedir.

A negative relationship is also found between economic growth, measured by GDP per capita, and carbon dioxide emissions for developed European countries only. In other words, these developed economies are reducing their CO2 levels as they progress. A similar situation does not exist, however, for developing economies. Based on the assumption that our developed economies exceed the income threshold mentioned by Arouri et al. (2012), these empirical results support the EKC hypothesis. Additionally, we find that air quality decrease with population levels, s, and energy consumption. The effects are significant both in the short- and long-term only for the developed economies sub-sample.

The impact of green investments on air quality varies between developed and developing European countries. Air quality in developed European countries is influenced by green investment, GDP, trade openness, and urbanization. In addition, Emirmahmutoğlu and Köse's (2011) causality tests confirm this result. This general result suggests that green investment flows should be regulated according to economic development levels. Additionally, it may be argued that green investment could be encouraged further in developing economies, such as the Czech Republic, Poland, and Romania with high CO2 emissions.

Due to the increasing demand for energy, the volatile oil market, and concerns about global warming, investments have been turning to clean energy, specifically green finance. A growing number of governments, financial institutions, investors, and businessmen are investing in environmentally-friendly technologies. The green investment revolution offers solutions to the energy crisis, the depletion of fossil fuels, and the shortage of natural resources. As a result of the use of renewable energy sources and other environmentally friendly technologies, socioeconomic growth is stimulated. In addition, investors around the world have access to exciting investment opportunities. Green investment is expected to become more popular shortly due to growing environmental awareness and increased government support for clean energy. (Brown, 2011).

Declarations

Authors Contributions

Metin İlbasmış: Conceptualization; Visualization

Mücahit Çitil: Validation; Visualization; Data curation

Furkan Demirtaş: Writing, Validation

Muhammad Ali: ; Methodology, Writing - original draft

Abdulkadir Barut: Conceptualization; Formal analysis; and Corresponding.

Mohammad Mohsin: Writing, Validation

Ethics approval and consent to participate Not applicable.

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Data availability Data set used in the study can be obtained by a reasonable request from the corresponding author

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