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RESEARCH ARTICLE

Electricity Production Sources and CO_2 Emission in OECD countries: Static and Dynamic Panel Analysis

Liton Chandra Voumik[1], Md. Jamsedul Islam[2], Asif Raihan[3*]

[1]Department of Economics, Noakhali Science and Technology University, Noakhali 3814, Bangladesh. Email: litonvoumik@gmail.com

[2]Department of Tourism and Hospitality Management, Noakhali Science and Technology University, Noakhali 3814, Bangladesh. Email: mjirafi.thm@nstu.edu.bd

[3]Institute of Climate Change, Universiti Kebangsaan Malaysia, Bangi 43600, Malaysia. asifraihan666@gmail.com

Corresponding Author: Asif Raihan, asifraihan666@gmail.com, ORCID ID: 0000-0001-9757-9730

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Abstract

Industrialization, urbanization, population growth, and changes in lifestyle have all contributed to a rise in the OECD countries' risk of global warming. The amount of carbon dioxide (CO_2) generated from heat and power sources put out is directly related to how much electricity they make. Finding out which sources are bad for the environment, and which are not is the primary motivation behind this study. The impact of different approaches to energy production on carbon dioxide emissions is analyzed using OECD data. The data is analyzed using Quantile Regression (QR), Generalized Method of Moments (GMM), and Pooled Ordinary Least Squares (OLS). The study found that CO_2 emissions were significantly impacted in a positive direction when electricity was generated using coal, oil, or gas. The emissions from coal-fired power plants are the most detrimental. The generation of hydroelectricity and other forms of renewable energy can reduce CO_2 emissions in all regression models. The most compelling evidence of a correlation between CO_2 emissions and energy sources was uncovered in this study. In order to produce credible findings, the paper used both QR and GMM methods. Important implications for environmental policy are drawn from this article's findings. Both are required to lessen our reliance on fossil fuels and promote the development of renewable energy sources like solar, wind, and hydroelectricity.

Keywords: Carbon dioxide; Environmental impact; Economics; Renewable; Sustainability

Introduction

As the global economy grows, CO_2 emissions rise because of industrialization, deforestation, environmental damage, and the world's population (Raihan et al., 2018; Raihan et al., 2019; Jaafar et al., 2020; Raihan et al., 2021; Raihan and Tuspekova, 2022a). According to the World Meteorological Organization (2021), the amount of carbon dioxide in the air has increased by 2.5 times since the beginning of the industrial revolution. CO_2 can be emitted into the environment during the generation and consumption of energy (Raihan and Tuspekova, 2022b; Raihan et al., 2022a; Raihan et al., 2022b). The amount of greenhouse gases (GHGs) in the earth's atmosphere has significantly increased due to higher energy use and it has had numerous negative impacts on the environment, people's health, the economy, and many others (Begum et al., 2020; Raihan et al., 2022c; Raihan and Tuspekova, 2022c). More than 80% of the world's energy needs grew between 2000 and 2010. Most of this growth was made possible by using more than twice as many fossil fuels. Over 90% of all CO_2 emissions and over two-thirds of all GHG emissions come from burning fossil fuels and biomass (Raihan and Tuspekova, 2022d; Raihan et al., 2022d). This makes CO_2 the most critical factor in determining the overall GHG emissions trend (Raihan and Tuspekova, 2022e; Raihan et al., 2022e; Raihan et al., 2022f).

Most of the emissions in many countries come from the transportation and energy sectors (Raihan and Tuspekova, 2022f; Raihan and Tuspekova, 2022g). Since 2000, the OECD's economy has grown steadily, but CO_2 emissions related to energy have gone down. This has happened because of changes in the economy's structure and the energy supply and because manufacturing has become more energy efficient. Most OECD countries are on track to meet their Kyoto Protocol emission reduction goal although the progress is not good enough. Because energy use and CO_2 emissions have recently increased, GHG levels will likely rise. Approximately 29% of GHG emissions in OECD countries come from the energy sector, 24% from transportation, 13% from manufacturing, 9% from agriculture, 7% from industrial processes, and 3% from waste (IEA, 2019). After three years of stability, CO_2 emissions from the world's energy sector hit a record high of 32.8 billion tons in 2017. In 2018, the average amount of CO_2 each person in OECD countries put into the air was 8.7 tons, while the average amount for the rest of the world was 4.3 tons.

Rapid economic expansion in OECD nations has coincided with an increase in energy usage for manufacturing, industrial, and service-oriented economic activities. Carbon, which is mainly used to make electricity and makes up most of the area's energy mix, has been the fastest-growing energy source in the OECD region over the last ten years. Even though this has helped the region grow and become more industrialized, it has also increased CO_2 emissions from energy use and air pollution, which is detrimental to human health (Raihan and Tuspekova, 2022h). Access to electric power sources has increased dramatically since 2000. Nonetheless, 45 million individuals living in the OECD region still don't have access to electricity, and many use biomass energy as their primary source of cooking fuel (IEA, 2019). However, energy consumption in OECD countries has been rising at a rate of 6% annually, indicating that the region's electric grid is having trouble covering its costs due to rapid population growth (IEA, 2019). In terms of global power consumption, it has been one of the regions with the quickest growth rates, with OECD nations leading the way. Indeed, the region has come a long way toward its objective of ensuring that everyone has access to power by 2030.

There may be numerous advantages to producing electricity for human usage. It could, however, hurt the environment and people's lives (Raihan and Tuspekova, 2022i; Raihan and Tuspekova, 2022j). Electricity can be produced in several ways, not all of which have the same environmental impact. Compared to other forms of renewable energy, such as solar power, the environmental impact of coal is substantially larger. In addition to nuclear and hydroelectric power facilities, oil can also be used to generate electricity. Coal, oil, and natural gas are frequently burned to generate electricity (Raihan and Tuspekova, 2022k). These factors contribute to the increase of carbon dioxide in the atmosphere. However, the location of power generation, transmission, and distribution can significantly alter the environmental consequences of the power system. Electric power systems also include transmission networks, distribution lines, and power plants that generate electricity from various fuel sources. Both the production and consumption of these items have the potential to have an impact on the natural world. Construction, electricity generation, component isolation, and separation fall within this category. The functional and construction effects can be further subdivided into operational effects (such as fuel sources and global and local pollutants) and building effects (manufacturing, installation, decommissioning, and disposal). However, energy-producing CO_2 emissions have not been the focus of any GMM or QR-based studies in the OECD region. Therefore, this research intends to identify a connection between CO_2 emissions and the sources of power generation in the OECD region using various methods, including System GMM, Difference GMM, and Quantile Regression. This article illustrates how much carbon dioxide is released from coal, gas, and oil electricity production in OECD countries. This study also demonstrated the advantageous effects of non-conventional methods of electricity production on the environment. This investigation aims to discover evidence that hydropower and other renewable energy sources can aid in decreasing waste and pollution. The environmental policy has been suggested in the article with the knowledge gained from this investigation.

Literature Review

The literature review overviews the relevant publications picked for the study endeavor. Numerous works have examined the relationship between power generators, renewables, and emissions of carbon dioxide. On the other hand, it's unclear how things happened because they happened in different ways, in different countries, and at different times. How much energy we use and how that affects CO_2 emissions is a big worry for people living now and in the future. Global citizens are already planning for the future consequences of climate change. Because of the harm, it does to the ecosystem; this is a dangerous situation. Dantama et al. (2012) reported that electricity influences all spheres of society, from the working class to the upper crust. According to numbers from 72 different countries, global CO_2 emissions increased from 67 million metric tons in 1990 to 134 million metric tons in 2012. So, environmental pollution kills more than 150,000 people yearly (Amri, 2017). Furthermore, Ozturk (2010) also linked various energy sources to economic growth. He examined several electricity sources. Population size, the quantity of renewable, fossil, and carbon-intensive energy used, nuclear-intensive energy used, over dense cities, and detrimental air pollutants like PM10, PM2.5, SO2, NO2, CO, and benzopyrene have all been related to the rise in global CO_2 emissions (Talbi, 2017). They also showed how these variables enhance global CO_2 emissions. Geothermal plants emit CO_2 due to their high temperatures (300–700 °F). The association between energy use, GDP expansion, and CO_2 emissions were examined using Granger causality and panel cointegration (Kristmannsdóttir and Armannsson, 2003). 70 countries' worth of data were analyzed from 1994-

2013. Granger causality studies show that the two are related to one another in terms of energy usage and carbon dioxide emissions. Cointegration tests demonstrated a long-term relationship between the variables of interest (economic growth and energy consumption) and CO_2 emissions. As a result of process fixes, rising energy use and economic growth led to lower CO_2 emissions. Economic activity, electricity concentration (demand strategy), heat production (supply strategy), and carbon emission index are all taken into account in this method of categorizing CO_2 emissions (demand policy effort). EU nations cut CO_2 more than non-EU nations. Reducing thermal power and increasing energy efficiency drove policy. These increases may be due to a shift in generation mix or higher power use. Scientists proved it (Kim et al., 2020).

Massive energy use and CO_2 emissions threaten future generations. Droughts, melting glaciers, rising seas, global warming, and heat waves are already happening. Negative environmental effects threaten the ecology. Between 1992 and 2018, Awosusi et al. (2022) analyzed the impact of BRICS biomass energy use. Environmental degradation is a byproduct of economic development, increased use of natural resources, and rising levels of gross capital. The research of Aydin (2019) relied on BRICS statistics from 1992-2013. Biomass energy's economic significance was emphasized. The heterogeneous panel data study benefited several nations. Biomass energy use is key to economic growth and reducing imports. Shisong et al. (2018) employed a quantile regression panel approach to estimate CO_2 emissions. According to their analysis, nonrenewable energy reduces CO_2 emissions the greatest. It is detrimental for high-emission nations to have little involvement in developing ecologically sound sources of power. Yu et al. (2019) investigated the effect of energy output on industrial development and long-term economic growth by concentrating on the nations with the most significant gains in power generation between 2000 and 2018.

From 1991 to 2018, the BRICS nations' electricity production contributed to industrial output and sustained economic growth. A few examples of these fields are manufacturing, raw materials extraction, mining, and chemical synthesis. It has significantly increased the electrification of all enterprises and households during the previous three decades (Wang et al., 2010). Apparently, the causal relationship between energy generation sources and CO_2 emissions has not been explored in OECD states. In addition, no other studies used system GMM, Difference GMM, and the QR approach to uncover useful information on CO_2 emissions from various power production sources in OECD countries. Consequently, the present study's results would help close a gap in the existing body of literature by using various econometric methods to identify a connection between CO_2 emissions and the sources of power generation in the OECD region.

Methodology

Data and variables of the study

Data for 38 OECD countries were obtained from the World Bank's World Development Indicators (WDI) database on an annual panel basis from 1986 to 2020. There are currently 36 member states of the OECD: Slovak Republic, Slovenia, Spain, Czech Republic, Denmark, Estonia, Finland, France, Netherlands, Norway, Poland, Portugal, Luxembourg, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Austria, Belgium, Japan, Korea, New Zealand, Israel, Switzerland, Canada, Chile, Colombia, Mexico, Costa Rica, the United States, Australia, Sweden, Germany, Turkey, the United Kingdom, and Lithuania. The following elements are taken into consideration (Table 1):

Table 1. A brief overview of the parameters

Name of the Variables	Variables in Log form	Elaboration of the Parameters
CO_2	$L(CO_2)$	CO_2 emissions (kt)
Coal	L(Coal)	Percentage of total electricity production that comes from coal
Gas	L(Gas)	Percentage of total electricity production that comes from gas
Nuclear	L(Nuc)	Percentage of total electricity production that comes from nuclear
Hydro	L(Hydro)	Percentage of total electricity production that comes from hydro
Oil	L(Oil)	Percentage of total electricity production that comes from oil
Renewable	L(Renew)	Percentage of total electricity production that comes from renewable resources excluding hydro

For a complete breakdown of how each variable was measured, the median, mode, standard deviation, and extreme values are displayed in Table 2. CO_2 has an average value that is greater than those of the other variables.

Table 2. Synopsis of Descriptive Statistics

Variables	Number of observations	Mean	Standard deviation	Minimum	Maximum
$L(CO_2)$	1172	11.17	1.707	5.458	15.57
L(Coal)	891	2.760	1.787	-6.483	4.587
L(Gas)	988	2.162	1.756	-4.785	4.599
L(Oil)	1071	0.864	2.017	-6.091	4.605
L(Renew)	961	0.467	1.924	-8.028	4.181
L(Hydro)	968	1.860	2.253	-6.528	4.601
L(Nuc)	867	3.347	0.789	-2.433	4.477

Econometric model specification

Coal, gas, oil, renewable energy, nuclear, and hydroelectricity are the main ways electricity can be produced. Though there are many ways to produce electricity, but there is no available data for these sources. Using the standard methodological approach, this investigation controls CO_2 emissions by measuring the impact of power generation from coal, natural gas, nuclear, hydroelectric, oil, and renewable sources. The following equation (1) may be used to determine the influence of dependent and independent variables.

CO_2 = *f* (Coal, Gas, Oil, Renewable, Hydroelectric, Nuclear) (1)

Notably, no dummy variables were included; all variables were classified. This is because it is anticipated that data behavior would not change over time. The multivariate econometric model is depicted in Equation (2).

$$(CO2)_{it} = \beta_0 + \beta_1(Coal)_{it} + \beta_2(Gas)_{it} + \beta_3(Oil)_{it} + \beta_4(Renew)_{it} + \beta_5(Hydro)_{it} + \beta_6(Nuc)_{it} + \varepsilon_{it} \quad (2)$$

The log transformation has been taken in Equation (3).

$$L(CO2)_{it} = \beta_0 + \beta_1 L(Coal)_{it} + \beta_2 L(Gas)_{it} + \beta_3 L(Oil)_{it} + \beta_4 L(Renew)_{it} + \beta_5 L(Hydro)_{it} + \beta_6 L(Nuc)_{it} + \varepsilon_{it} \quad (3)$$

where β_0 is the intercept term. β_1, β_2, β_3, β_4, β_5, and β_6 are the slope coefficients. The ε is present the residual, and i presents the cross-section country, t presents the time.

GMM approach

Researchers often utilize both fixed and random effects models when studying topics such as international trade, environmental policy, and economic development. The dynamic GMM model, developed by Arellano and Bond (1991) has only recently begun its operations in these sectors. This study used models with fixed and random effects separately so that their findings can be compared with those obtained from our dynamic model. In order to conduct an investigation into the CO_2 emissions, a two-stage "differenced" and "system" GMM model has been included in this investigation. Formulae for the differenced GMM and system GMM can be displayed as Equation (4) and Equation (5).

$$L(CO2)_{it} = \beta_0 + \beta_1 L(CO2)_{it} + \beta_2 L(Coal)_{it} + \beta_3 L(Gas)_{it} + \beta_4 L(Oil)_{it} + \beta_5 L(Renew)_{it} + \beta_6 L(Hydro)_{it} + \beta_7 L(Nuc)_{it} + \varepsilon_{it} \quad (4)$$

$$L(CO2)_{it} - (CO2)_{it-1} = \beta_0 + [\beta_1 L(CO2)_{it} - (CO2)_{it-1}] + [\beta_2 L(Coal)_{it} - (Coal)_{it-1}] + [\beta_3 L(Gas)_{it} - (Gas)_{it-1}] + [\beta_4 L(Oil)_{it} - (Oil)_{it-1}] + [\beta_5 L(Renew)_{it} - (Renew)_{it-1}] + [\beta_6 L(Hydro)_{it} - (Hydro)_{it-1}] + [\beta_6 L(Nuc)_{it} - (Nuc)_{it-1}] + (\eta_{it} - \eta_{it-1}) + (\varepsilon_{it} - \varepsilon_{it-1}) \quad (5)$$

Quantile regression (QR regression)

One important use of the quantile regression method is to study outcomes that aren't normally distributed and don't have linear relationships with predictor factors. Buchinsky (1994) states that to describe the possible different effects, it needs to identify the qth-quantile (0< q<1) of the dependent variable as a temporary distribution, given a set of x_i variables as follows:

$$Q_q\,(y_{it} \mid \beta_0, \varepsilon_{it}, x_{it}) = \beta_0 + \varepsilon_{it}^q + \beta_i^q x_{it} \quad (6)$$

where y_t indicates the rate of CO_2 emission over time.
As seen by the following objective function, inference from the qth quantile regression requires minimizing the absolute value of the residual. Quantile regression is presented in Equation (7).

$$Q_q\left(\beta_i^q\right) = \min \beta \sum_{q,i,t=1}^{n} \| y_{it} - x_{it}\beta_i^q \| = \min \left[\sum_{i:y_{it} \geq x_{it}\beta} q \left| y_{it} - x_{it}\beta_i^q \right| + \sum_{i:y_{it} < x_{it}\beta} (1-q) \left| y_{it} - x_{it}\beta_i^q \right| \right] \quad (7)$$

Results and Discussion

Correlation analysis is crucial to know if there is a positive or negative correlation between the variables in the study. When two variables have a positive correlation, it can say that they are positively covariant. Negative covariance is formed when two variables have an inverse relationship. Table 3 correlations show a positive relationship between L(CO_2) and L(Coal), L(Oil), and L(Gas). The correlation between L(CO_2) and L(Coal) is the highest and most significant, while the correlation between L(CO_2) and L(Gas) is the lowest and least significant (0.014). Similarly, the strongest positive correlation is found between L(CO_2) and L(Coal) and the value is 0.360. There are no correlation coefficients that are greater than 0.80 between any of the variables in this research. As a result, there is no multicollinearity and the study's variables are not linked to one another. To a lesser extent than L(Nuc), L(Renew), and L(Hydro) have a negative correlation with L(CO_2).

Table 3. Indicators of variable correlation

Variables	L(CO_2)	L(Coal)	L(Gas)	L(Oil)	L(Renew)	L(Hydro)	L(Nuc)
L(CO_2)	1.000						
L(Coal)	0.360***	1.000					
L(Gas)	0.014	0.212***	1.000				
L(Oil)	0.197***	0.480***	0.089***	1.000			
L(Renew)	-0.098***	-0.017	0.303***	-0.260***	1.000		
L(Hydro)	-0.180***	-0.383***	-0.169***	-0.256***	0.140***	1.000	
L(Nuc)	-0.353***	-0.286***	-0.423***	-0.172***	-0.262***	0.264***	1.000

*** p<0.01, ** p<0.05, * p<0.1

Table 4. Unit Root Test Result

Variables	At Level			At 1st Difference		
	Harris-Tzavalis	Im-Pesaran-Shin	Levin, Lin & Chut	Harris-Tzavalis	Im-Pesaran-Shin	Levin, Lin & Chut
L(CO_2)	0.488	0.847	-0.471	-23.45***	-8.765***	-5.613***
L(Coal)	1.254	2.294	4.70	-32.44***	-9.213***	-7.29***
L(Gas)	-0.94	1.167	0.362	-32.10***	-8.956***	-5.15***
L(Oil)	1.2456	-0.863	-0.073	-21.25***	-9.33***	-7.88***
L(Renew)	-0.98	-0.736	-0.684	-31.83***	-9.247***	-7.82***
L(Hydro)	-1.11	0.617	0.545	-39.52***	-9.769***	-7.72***
L(Nuc)	-2.18	-1.054	-1.028	-44.82***	-10.75***	-9.687***

*** p<0.01, ** p<0.05, * p<0.1

Empirical economists frequently use panel unit root tests, although there is still room for debate on how to interpret the results. This note elaborates on how the rejection of the panel unit root hypothesis can be read as proof that a sizable fraction of the units are stationary. For this reason, it is suggested that, in the case of a rejection, especially in contexts where the temporal dimension of the panel is quite large, the test outcome be supplemented with an estimate of the fraction of the cross-section units for which the individual unit root tests are rejected. The rejection's monetary impact can be gauged by how much this percentage rises (Pesaran, 2012). The outcomes of a unit root test for the dependent and independent variables are shown in Table 4 for both the raw data and the first difference levels. Specifically, it shows that H(0) has a unit root since it is non-stationary, while H(1) does not. It is evident that all of the parameters are locked in at H(1). The null hypothesis is rejected with a confidence level of 5% if there is even a nominal difference between the two variables. The dependent and independent variables are anticipated to follow a unit root distribution. Here, the investigation would reject the null hypothesis if the p-value is less than 0.01.

As shown in Table 5, the log-log model estimates both fixed and moving information panels. The coefficient of CO_2 emissions and electricity output from various sources are presented in columns 2 and 3 of the model. The coefficient represents a percentage change in CO_2 emissions due to a percentage change in the independent variables. Our model's dynamic panel regression is shown in columns 4 and 5. The estimate is statistically significant and positive, with coefficients of L(CO_2) for explaining L(Coal) of 0.108*** and 0.109*** in the fixed and random effect models, respectively. The differenced GMM model predicts a 0.0629 percentage point rise in CO_2 emissions for a one percent increase in L(Coal), while the System GMM model predicts a 0.00802 percentage point decrease. Direct sources of CO_2 emissions are important, but indirect sources

including hard coal, natural gas, and non-energy consumption also contribute significantly (Huang et al., 2018). For cases where both L(Coal) and L(Oil) are major contributors to increasing CO_2 in a given panel research region, the second-phase output is determined by the dynamic GMM model. L(Renew) exhibits a -0.0101 and -0.0101 coefficient weighted negative and significant effect on L(CO_2) in both the fixed and random effect models. For the differenced GMM model, a 1% increase in L(Renew) leads to a 0.00605% rise in CO_2 emissions, while for the System GMM model, the growth is only 0.00485%.
In the same way, the Differenced GMM model predicts a 0.0417% drop in CO_2 emissions for a 1% rise in L(Hydro), while the System GMM model predicts a 0.0042% drop. Table 5's Haussmann chi-square value of 18.52** favors the fixed-effect model over the random-effects model, with a significance level of 0.125. The system GMM model only differs considerably in sign and direction from the fixed-effect model for L(Oil). To ensure the internal consistency of the system GMM estimate, it is assumed that the error term is not serially correlated. Due to the low AR-2 values for both models, we cannot conclude that the first-differenced error at order 2 is serially correlated. Methods that can be relied on are required for use in GMM estimations. Applying the Sargan and Hansen tests for over-identifying constraints in estimation allows one to examine the general validity of an instrumental variable. The null hypothesis assumed that all instruments were reliable because they were considered exogenous. This study shows that the Hansen test returns probabilities between 0.243 and 0.415. On the other hand, the Sargan test statistics of the present investigation yield probability values of 0.250 and 0.284. The null hypothesis that the instruments are reliable, was accepted for both.

Table 5. Dynamic and Static Panel Regression Result

Variables	Fixed effect	Random effect	Differenced GMM	System GMM
L(CO_2)			0.716***	0.980***
			(0.0629)	(0.00802)
L(Coal)	0.108***	0.109***	0.0779**	0.0130*
	(0.0142)	(0.0141)	(0.0335)	(0.00881)
L(Gas)	0.0797***	0.0801***	0.0411***	0.00583**
	(0.0113)	(0.0112)	(0.0134)	(0.00459)
L(Oil)	0.0374***	0.0377***	0.00896	0.00861
	(0.0103)	(0.0103)	(0.00561)	(0.00614)
L(Renew)	-0.0101	-0.0101	-0.00605	-0.00485
	(0.00665)	(0.00662)	(0.00520)	(0.00318)
L(Hydro)	-0.0629***	-0.0623***	-0.0417*	0.00421*
	(0.0139)	(0.0138)	(0.0296)	(0.00495)
L(Nuc)	-0.0358**	-0.0361**	-0.00215	-0.00666
	(0.0161)	(0.0160)	(0.00542)	(0.00853)
Constant	12.15***	12.07***	3.287***	0.207**
	(0.0847)	(0.377)	(0.727)	(0.101)
Hausman test		18.52**		0.004
AR-1				0.184
AR-2				
Hansen Test			0.243	0.415
Sargan Test			0.250	0.284
Number of instruments			306	334
Observations	805	805	675	692
R-squared	0.334			
Number of countries	28	28	25	26

*** p<0.01, ** p<0.05, * p<0.1

Furthermore, Column 2 of Table 6 displays the results of an OLS regression between CO_2 emissions and power generation from different sources. Colum 3 through Colum 5 display the regression quantiles. The QR model considers all three of these frequencies: Q25, Q50, and Q75. Coal and natural gas power plants produce more carbon dioxide as they generate more electricity. In the QR models for Q25, Q50, and Q75, the L(Coal) coefficients to explain L(CO_2) are 0.0607, 0.209***, and 0.481***, respectively. There is a negative and significant effect on L(CO_2) from both L(Renew) and L(Hydro), except for Q25. With quantile-specific L(Renew) values of 0.0235, -1.102*, and -0.0327, respectively, a 1% increase in L(Renew) sources generates a CO_2 emission barrier of 0.024%, 0.10%, and 0.034%. There is a statistically significant inverse relationship between carbon emissions and the generation of power from renewable and hydroelectric sources; this is an important factor to consider. Power generation from renewable, oil, and hydroelectric sources can thus contribute to improved environmental quality by lowering atmospheric carbon emissions. In addition, less carbon dioxide is released into the air when power generation is more streamlined.

Table 6. Quantile regression outcomes

Variables	Panel OLS	Q25	Q50	Q75
L(Coal)	0.258***	0.0607	0.209***	0.481***
	(0.0486)	(0.0830)	(0.0637)	(0.0336)
L(Gas)	0.316***	0.131	0.492***	0.268***
	(0.0707)	(0.121)	(0.0926)	(0.0489)
L(Oil)	0.346***	0.541***	0.211***	0.0846**
	(0.0611)	(0.104)	(0.0801)	(0.0422)
L(Renew)	-0.0171	0.0235	-0.102*	-0.0327
	(0.0455)	(0.0776)	(0.0595)	(0.0314)
L(Hydro)	-0.248***	-0.249	-0.127***	-0.08***
	(0.0427)	(0.0729)	(0.0560)	(0.0295)
L(Nuc)	-0.136	-0.216	-0.0683	0.0791
	(0.0841)	(0.143)	(0.110)	(0.0581)
Constant	10.79***	11.24***	10.39***	10.34***
	(0.373)	(0.636)	(0.488)	(0.258)
Observations	405	405	405	405
Number of ids	32			
R-squared	0.742			

*** p<0.01, ** p<0.05, * p<0.1

In most cases, coal, oil, and gas are the primary fuels utilized in the generation of electrical power. Degradation of the local environment is exacerbated by these countries' use of fossil fuels for energy production, particularly coal, oil, and natural gas. The present study focused on answering the question of what can be done to reduce the carbon dioxide emissions of power plants. It is untrue to assume that the only way carbon dioxide is released into the atmosphere is through the burning of fossil fuels like coal, oil, and gas. Our novel approach to this issue is based on a hybrid of the conventional least squares method, a variant of the method of moments, and the quantile regression technique. No other scientific study has ever attempted something like this before. Because this study care about the accuracy of both the methods and results, this investigation consistently mixes the two. Massive increases in CO_2 emissions are produced when fossil fuels like gas, coal, and oil are burned. It is possible that switching to renewable energy sources like hydropower might drastically reduce pollution levels (Voumik et al., 2022a; Voumik et al., 2022b; Voumik et al., 2022c) The GMM method proves that burning coal and extracting oil are the two leading causes of CO_2 emissions. CO_2 emissions may be reduced, however, if power is generated from renewable and hydroelectric sources, as shown by the GMM approach. Quantile regression analysis of emissions data provides some context, showing that coal and natural gas are the two most important contributors to air pollution and, by extension, global warming. Hydropower and other renewable energy sources have the potential to aid in emission reductions, as shown by the GMM and Quantile Regression methods. Hydroelectricity and other forms of renewable energy are favored by all economic models as the most effective means of minimizing harmful effects on the environment (Huang et al., 2018; Aydin, 2019). Coal-fired energy is much more damaging to the environment than other forms of pollution. This study's aims are met as a result as well. It is generally accepted that the environmental impact of electricity generated by burning coal is more significant than that of power generated by burning oil or natural gas. However, hydroelectricity production is better for the environment than renewable energy sources that don't use hydropower. This paper's contribution quantifies how the independent factors affected the dependent ones. Potentially significant long-term renewable energy sources include wind, solar, geothermal heat, and biomass. The majority of OECD countries get their power from coal and oil. Coal and gas consumption in the OECD as a whole has expanded quickly since 1980; however, consumption has declined in some countries like New Zealand and Norway, and demand in the United States currently surpasses output, which is rising at a high rate.

Conclusions and Policy Implications

This study examined the relationship between energy consumption and carbon dioxide emissions in OECD economies. Using panel generalized methods of moments (GMM) and quantile regression, this research analyzed time series data on OECD nations from 1986 to 2020. The research empirically assessed the impact of different power generation sources on CO_2 emissions using quantile regression and generalized linear models (GMM). When compared to traditional statistical methods like ordinary least squares (OLS), generalized linear models (GLM), and additive random effects (ARDL), quantile regression, one step-difference GMM, and system GMM provide a more comprehensive explanation of the overall dependence of energy generation from diverse sources on CO_2 emissions. As a result of their more significant outputs, coal and natural gas have more prominent production factors. Production rates of renewable energy are inversely proportional to their ecological footprint. Because of the positive ecological effects, renewable energy sources should be prioritized above traditional ones. CO_2 emissions and energy generating sources are positively correlated in OECD countries. Hydroelectric power generation also can lessen its impact on the environment. Thus, renewable energy sources are preferable to conventional electricity generation methods. Natural gas and coal are two of the most widely used energy sources, and all of our models for OECD nations indicated a high positive correlation between the two in terms of CO_2 emissions. Regardless, the oil-based power generation didn't give us any direct orders.

This article provides a clear and consistent picture of the current state of renewable energy sources in OECD countries. Since most OECD nations have abundant natural resources, this article shows they have a great chance to meet their overall power demand by using their renewable resources, such as solar, wind, geothermal, hydropower, ocean energy, and bioenergy. If they can maximize their usage of renewable energy sources, not only will their electricity needs be met at a low cost, but their CO_2 output may also be kept to a minimum. So, instead of relying solely on conventional ways, now is the time to look forward and collaborate with these renewable energy areas to produce electricity. There has already been some effort made by OECD governments to resolve the power situation. Alternative energy sources, such as solar power, should be given more attention because they represent a promising new industry with the potential to supply the vast majority of the OECD's population's energy and power needs. Combined with other forms of renewable energy, these can significantly help meet their daily power needs. OECD countries may be able to meet their future electricity needs using these resources to generate electricity. To alleviate the power shortage situation in their respective regions, governments and the private sectors should collaborate to emphasize using renewable energy sources for electricity generation. The article also provides a brief overview of the current state of renewable energy worldwide. With fossil fuel reserves continuously dwindling, the world must increasingly rely on renewable energy sources to keep up with increasing energy demands. By maximizing the utilization of renewable energy sources, this article is the first step toward building a completely uninterrupted power flow that is both environmentally friendly and efficient.

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