INTERNATIONAL JOURNAL OF ENERGY STUDIES

Determinants of fossil fuel subsidies: Analysis of economic, environmental, and institutional factors using a dynamic panel data approach

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Highlights
• Analayis the effects of renewable energy, government effectiveness, and CO2 emissions on FFS.
• Use annual data from 2010 to 2022 and dynamic panel estimators (System-GMM and Difference-GMM).
• The findings provide strong evidence that REN, CO2, and GOV reduce FFS.

<u>You can cite this article as:</u> Barak D. Determinants of fossil fuel subsidies: Analysis of economic, environmental, and institutional factors using a dynamic panel data approach Int J Energy Studies 2025; 10(4): 1511-1529.

ABSTRACT

One of the obstacles to sustainable development goals (SDGs) is fossil fuel subsidies (FFS), which have economic, environmental, and social impacts. In addition, it is important to identify the factors that determine FFS. Although FFS have declined in recent years, they remain at high levels. Therefore, the aim of this study is to reveal the effects of three critical variables that shape the economic, environmental, and social impacts of FFS in 45 countries: renewable energy (REN), CO2 emissions (CO2), and government effectiveness (GOV). For this purpose, based on annual data from 2010 to 2022, the relationship between the variables was determined using Driscoll-Kray and Panel-Corrected Standard Errors (PCSE) estimators, along with dynamic panel estimators (system GMM and difference GMM). The findings provide strong evidence that REN, CO2, and GOV reduce FFS, while per capita income increases them. Policy makers can gradually phase out FFS by promoting REN investments and strengthening public governance to achieve SDG targets.

Keywords: Fossil fuel subsidies, Renewable energy, Government effectiveness, Dynamic analysis

1. INTRODUCTION

FFS are one of the tools governments use to intervene directly or indirectly in energy markets and are defined as support mechanisms aimed at reducing the production or consumption costs of fossil fuels [42]. These subsidies have a cost-reducing and, consequently, competitiveness-enhancing effect, particularly in countries where energy prices play a decisive role in economic growth. The decline in energy costs provides a cost advantage in production processes; this advantage is then reflected in the final product prices. Lower prices make the products of countries applying subsidies competitive in global markets and create a demand-boosting mechanism. Thus, FFS not only reduce energy costs but also generate trade-creating and growth-accelerating effects.

However, in today's world where global warming and environmental degradation are becoming increasingly visible problems, the negative impacts of FFS on environmental sustainability are being intensely debated by researchers. CO2 emissions caused by fossil fuels are cited as one of the main causes of climate change. Despite this, FFS remain high even today, when environmental sensitivity is at its peak. According to 2022 data, FFS account for 7.1% of global GDP [8]. Global FFS fell significantly in 2023 to approximately $1.10 trillion after reaching a record high in 2022. This decrease represents a significant 34.5% reduction compared to the previous year [39]. This situation points to a deep contradiction between economic growth targets and environmental sustainability.

Countries are implementing plans to promote the use of REN with the aim of eliminating these potential long-term problems caused by FFS. Although some studies indicate that in the short term, the cost of using REN sources will be higher than the cost advantage of fossil fuel use created by FFS, in the long term, this cost will be reversed. In the long term, air and environmental pollution caused by fossil fuel use will have an effect that increases global warming. This increase has the potential to replace the gains planned to be achieved in the short term with irreparable disasters [7, 21, 31]. FFS are broadly seen as counterproductive—they skew market prices and consumer behavior, while channeling government resources away from environmentally responsible growth. They also pose risks to economic stability and hinder progress toward climate targets. FFS encourage excessive consumption, hinder the adoption of renewable energy, and create market inefficiencies that exacerbate geopolitical risks [46]. On top of that, the lack of transparent and consistent reporting makes it difficult for analysts to grasp their full impact [39].

The implementation of FFS increases the costs of REN, thereby negatively impacting competitiveness [16]. FFS has had unforeseen consequences, such as market distortions, decreased investment in low-carbon technologies, and obstacles to transitioning to more sustainable energy sources [11]. However, with the widespread use of REN, countries can achieve the planned increase in national welfare through SDGs, energy supply security, and energy access goals, similarly to how they aim to achieve it with FFS. In addition to enhancing energy access and supply security, this method will also decrease fossil fuel dependency rates. Therefore, it will create an alternative in international competition, which is another goal. In addition to securing similar gains to those that FFS provides, the REN will make significant contributions to eliminating the global climate change problem that air and environmental pollution causes in the long term and to achieving SDGs. For these reasons, examining the relationship between REN and FFS plays an important role in determining countries' short- and long-term goals.

In addition, scholars have emphasized that FFS are a government policy. Therefore, the government's economic growth target, as well as measures that consider sustainable development and environmental issues, are also factors that influence FFS. The implementation of effective public policies and strong structural reforms by governments will enable them to direct subsidies in a more rational manner that takes environmental issues into account [7, 41]. Therefore, examining the relationship between GOV and FFS is important because it will directly influence the policies that countries will implement.

Therefore, this study aims to examine the link between FFS, REN, and GOV using data from 45 countries between 2010 and 2022. In addition to this objective, this study will also draw conclusions regarding the relationship between economic growth, environmental sustainability, and FFS. A review of the relevant literature reveals that only a limited number of studies focus directly on the determinants of FFS. Furthermore, this research empirically examines how REN, CO2 emissions, and GOV—three critical variables shaping the economic, environmental, and social sustainability of FFS—affect subsidies in these countries. Therefore, our analysis of these variables is crucial for both policymakers and the academic literature..

To this end, the following steps are taken: The theoretical framework of the study is presented in the second chapter. The third chapter contains a comprehensive literature review addressing the topics of the study. The same chapter also covers the data set and model section. Finally, the

findings obtained because of the analyses performed in the methods section are presented, and conclusions and recommendations are offered based on these findings.

2. THEORETICAL FRAMEWORK

The environmental, financial, health, and economic impacts of FFS can become apparent. Therefore, there is debate about why these subsidies continue and what determines the success of subsidy reform. The removal of FFS is the first step toward proper energy pricing and reflects the true and full cost of fossil fuels to society and the environment. However, if poorly planned, FFS reform could lead to price increases that disproportionately affect the poorest households and trigger social unrest [40].

Hayer [19] has pointed out a series of complex social, economic, and political obstacles behind the continuation of FFS. Public lack of awareness, interest groups that hinder reforms, and governments' lack of institutional capacity make it difficult to change this policy. Furthermore, public distrust of the government, concerns about the social impact of price increases on the poor, and fears that removing subsidies will trigger inflation and negatively impact the economy, particularly during periods of weak macroeconomic conditions, increase public resistance to subsidy removal [19].

In the same study, Hayer [19] outlined how a successful subsidy reform could be implemented. The first step is to conduct a detailed analysis of existing subsidies. Throughout the process, transparent dialogue must be established with all stakeholders to secure public support. Investment should be made in targeted social policies that protect vulnerable groups, without shifting the burden of reform onto their shoulders. Ultimately, subsidies should be phased out with clear objectives and a realistic timeline, and institutional capacity should be strengthened to manage this process [19].

Droste et al. [16] have attempted to establish FFS reforms on a theoretical basis. Therefore, they have proposed a theory on the political economy of FFS reforms. This theory is made up of four interrelated components or processes: i) The market power mechanism of technologies and interests; this refers to a market power mechanism that captures the effects of competition between energy sectors and results in an increase in the share of REN, a decrease in the role of fossil fuels, and thus an easier reform of FFS. ii) The policy mechanism of effective reforms; this refers to a

policy mechanism whereby reforms lead to a decrease in overall FFS levels. iii) The governance mechanism of institutional quality (e.g., government effectiveness, control of corruption); this refers to a governance mechanism whereby institutional quality affects the feasibility and effectiveness of policy reforms. Elected democracy plays a supportive role in strengthening the positive relationship between the REN and FFS reforms. iv) A feedback mechanism that reinforces lock-in; the higher the current FFS, the more difficult it is for REN sources to enter the market.

The larger the market share of REN, the easier it becomes to reform FFS. Higher-quality political institutions reduce the likelihood that coalitions supporting FFS will block subsidy reform. Greater government effectiveness typically resulted in increased reform efforts, which in turn contributed to a reduction in subsidies [16].

3. LITERATURE

The economic [20], social [35], and environmental [36] impacts of FFS have been frequently discussed in the literature, and debates on this topic continue. Governments generally implement subsidies on the grounds of alleviating poverty, redistributing national wealth, or promoting economic development by supporting energy-consuming industries [33]. In addition, there are studies focusing on the determinants of FFS. Saddıkı and Chaoutı [33] identified the significant financial burden on state budgets, economic inefficiency, pressure from falling international oil prices, growing environmental concerns, obligations under international climate agreements, and the influence of donor countries and organizations as the main reasons for reducing FFS. In contrast, they stated that the main obstacles to fossil fuel reforms include the general lack of public trust in the government, unfavorable economic conditions that increase public sensitivity to price increases, concerns about the serious impact on low-income households and their welfare, and political resistance from sectors that receive strong subsidies. Moghaddam and Wirl [26] emphasized that high oil revenues in oil and gas exporting countries lead to increased subsidies and make it difficult for governments to remove them. Mahdavi et al. [24] showed that fossil fuel taxes are determined by a country's revenue needs rather than its political institutions or environmental commitments. Foo et al. [17] concluded that GDP and government effectiveness in Asia-Pacific Economic Cooperation (APEC) economies are negatively correlated with local domestic fuel prices.

Martinez-Alvarez et al. [25] examined the impact of leaders on fossil fuel taxes and subsidies in 155 countries and showed that the impact of leaders is limited and often temporary. Gasim et al. [18] investigated the conditions and outcomes of 400 different energy subsidy reforms implemented in 43 countries and found that larger energy price increases are more likely to trigger social unrest or lead to the reversal of reforms. Cheon et al. [12] analyzed gasoline subsidies using data on gasoline prices in 137 countries and found that policy interventions that increase institutional capacity can help countries reduce FFS. Tavakolian et al. [38] assessed the determinants of FFS in selected exporting countries. Their results indicated that carbon emissions and health costs influence gasoline subsidy payments. Van Beers and Strand [41] investigated the economic and political determinants of gasoline and diesel prices in 200 countries. They found that in democracies, fuel prices correlate positively with both the duration of democracy and the tenure of democratic leaders. They noted that in non-democratic societies, there is generally no such relationship or that the relationship is the opposite of that in democracies. Olanrewaju et al. [28] examined the effect of the ESG-based sustainability uncertainty index on fluctuations in fossil fuel energy prices. The results indicate that the ESG-based sustainability uncertainty index has a predominantly negative short-term effect on oil, heating oil, and natural gas prices under low-trend or moderately active market conditions. Drake and Skovgaard [14] have shown that coal production subsidies in Germany and gas production subsidies in Canada help governments remove FFS through political insulation and compensation. Droste et al. [16] scrutinized the empirical and theoretical foundations of FFS reforms in 35 OECD countries and presented evidence that REN and institutional quality can significantly facilitate FFS reform.

Based on the theoretical work of Droste et al. [16] and the literature reviewed, the following hypotheses were formulated:
H1: REN has a reducing effect on FFS.
H2: GOV has a reducing effect on FFS.

Our motivation differs from previous studies. Droste et al. [16] propose a theory examining FFS reforms within a political economy framework. They note that the success of FFS depends not only on the strength of economic arguments but also on a complex political balance. Therefore, Droste et al. [16] suggest that it would be useful to investigate whether higher institutional quality increases the FFS reforms. They also state that as the market share of clean energy grows, it becomes easier to reform FFS. Building on this, this study examines the impact of social

(government effectiveness), economic (per capita income), and environmental (renewable energy and CO2 emissions) factors on FFS across 45 countries over an extended period. Thus, this study aims to empirically test the theoretical framework proposed by Droste et al. [16] and contribute methodologically and empirically to the literature on the determinants of FFS.

4. DATA AND MODEL

This study examines the impact of REN, GOV, GDP, and CO2 emissions on FFS across 45 countries using annual data from 2010 to 2022 based on the availability of data on FFS. The dependent variable, FFS, is measured in dollars per capita. The independent variables are REN, calculated as kWh per capita equivalent, and GOV, which is an index ranging from -2.5 (weak governance performance) to +2.5 (strong governance performance), taken as an indicator of institutional structure. Per capita income, as an indicator of economic growth, is measured in constant 2010 US dollars. CO2 emissions are taken as tons per capita. FFS were obtained from the OECD [27] database. GOV and per capita income data were taken from the World Bank [43] database. REN and CO2 emissions were obtained from Our World in Data [30]. Table 1 shows the description and measurement of the variables used. The list of countries is given in Appendix 1.

Table 1. Definition of variables

Variables	Symbol	Measurement	Source
Fossil fuel subsidies	FFS	per capita million dollars	OECD [26]
Renewable energy consumption	REN	per capita kWh – equivalent	OWD [28]
CO2 emissions	CO2	tones per person	OWD [28]
Government effectiveness	GOV	index	WDI [41]
Per capita income	GDP	constant 2010 US dollar	WDI [41]

The values of other variables (FFS, REC, and GDP) outside of government activity have been converted to logarithmic form. Table 2 shows the descriptive characteristics of the variables examined for all years considered.

The minimum (Min.) value of the FFS is -4.509, the maximum (Max.) value is 7.220, and the standard deviation (Std. Dev.) is 1.309; the min. value of REN is 4.421, the max. value is 11.274, and the std. dev. is 1.191. These figures indicate significant differences between countries in terms of subsidy and renewable energy policies. GOV has a min. value of -0.813, a max. value of 2.235, and a std. dev. of 0.730. CO2 has a std. dev. of 0.618, a min. value of 0.272, and a max. value of 3.094. The max. value for the CO2 variable is approximately 10 times higher than the min. value. This also reveals a certain difference in environmental policies between countries. GDP has a std. dev. of 0.969, a min. value of 7.121, and a max. value of 11.612. Of all the variables considered, GDP exhibits the highest average value, whereas GOV records the lowest.

Table 2. Descriptive statistic

Variables	Obs.	Mean	Std. Dev.	Min.	Max.
FFS	579	4.273	1.309	-4.509	7.220
REN	546	8.316	1.191	4.421	11.274
CO2	585	1.744	0.618	0.272	3.094
GOV	585	0.924	0.730	-0.813	2.235
GDP	585	9.918	0.969	7.121	11.612

This article analyzes the determinants of FFS. Following the work of Droste et al. [16], the functional form of the estimated model is shown in Equation 1.

$$FFS_{it} = f(REN_{it}, CO2_{it}, GOV_{it}, GDP_{it}) \tag{1}$$

This functional form can be converted into a logarithmic regression equation. The econometric model we established to examine the effect of REN, GOV, per capita income, and CO2 emissions on FFS are described as follows:

$$FFS_{it} = \theta_0 + \beta_1 REN_{it} + \beta_2 CO2_{it} + \beta_3 GOV_{it} + \beta_4 GDP_{it} + e_{it} \tag{2}$$

Here, FFS represents fossil fuel subsidies, REN represents renewable energy consumption, GOV represents government effectiveness, GDP represents per capita income, CO2 represents per capita CO2 emissions, and e_{it} represents the error term.

5. METHODOLOGY

Various approaches exist for estimating panel data models, including Ordinary Least Squares (OLS), Driscoll-Kraay (D-K), Panel Corrected Standard Errors (PCSE), and Generalized Method of Moments (GMM). Both D-K [15] and PCSE [6] are statistical methods frequently used in the literature because they produce robust estimates in panel data estimation despite autocorrelation, heteroscedasticity, and CSD. Furthermore, both D-K and PCSE can provide robust estimates for both balanced and unbalanced panels. D-K uses a nonparametric technique. It is particularly suitable for long panels with temporal dimensions exceeding cross-sectional dimensions. However, the PCSE approach is suitable for panels with a large number of cross-sectional units (N) and a limited number of time periods (T). Furthermore, PCSE has been proposed as an alternative approach to OLS [6].

In our study, since N < T, difference-GMM and system-GMM estimators were applied to avoid biased results and control for endogeneity. Endogeneity issues may arise due to reverse causality, measurement errors, or omitted variable bias [13]. To overcome such problems and confirm the accuracy of the D-K and PCSE estimation results, GMM estimators were considered. Arellano and Bond [2] developed a GMM dynamic panel data estimator that includes lags of both dependent and independent variables as instruments [44]. Arellano and Bover [3], along with Blundell and Bond [9], introduced the system-GMM estimator as a solution to the problem of weak instruments. When explanatory variables show strong persistence over time, they may not serve as reliable instruments, potentially leading to biased outcomes with the Difference-GMM approach. To address this, the system-GMM method integrates both the differenced and level forms of the equations, enhancing the overall efficiency of the estimation [23]. The two-stage system GMM was developed to control for the possible presence of endogeneity, heteroscedasticity, and omitted variables [37].

OLS, Driscoll-Kraay, and PCSE methods are typically used to examine static associations among variables. To explore dynamic relationships, however, the model incorporates a lagged term of the dependent variable as an additional explanatory factor. Equation (3) outlines a broad structure for estimating models using dynamic panel data techniques.

$$FFS_{it} = \partial_0 + \partial_1 FFS_{i(t-1)} + \partial_2 REN_{it} + \partial_3 CO2_{it} + \partial_4 GOV_{it} + \beta_5 GDP_{it} + e_{it} \qquad (2)$$

where, $FFS_{i(t-1)}$ is the first lag of dependent variable (FFS) and e_{it} is error term. The symbol ∂ represents the parameters to be estimated.

6. FINDINGS, DISCUSSION, AND POLICY IMPLICATIONS

OLS, D-K, and PCSE estimation results illustrated in Table 3. The result indicates that REN, CO2 emissions, and GOV have a significant negative effect on FFS, while per capita income (GDP) has a positive effect.

Table 3. Baseline regression

Variable	OLS	DK	PCSE
REN	-0.249	-0.024	-0.249
	(0.000)	(0.000)	(0.000)
	[0.050]	[0.042]	[0.051]
CO2	-0.440	-0.440	-0.044
	(0.000)	(0.000)	(0.000)
	[0.078]	[0.069]	[0.043]
GOV	-0.827	-0.827	-0.827
	(0.000)	(0.000)	(0.000)
	[0.125]	[0.094]	[0.096]
GDP	1.604	1.604	1.604
	(0.000)	(0.000)	(0.000)
	[0.097]	[0.054]	[0.064]
Constant	-7.963	-7.963	-7.963
	(0.000)	(0.000)	(0.000)
	[0.799]	[0.555]	[0.502]
R2	0.335	0.335	0.335
Countries	45	45	45

( ) and [ ] indicate the probability and standard error, respectively.

On the other hand, we are following dynamic estimators for more robust findings. The Difference-GMM and System-GMM results applied as robustness tests provide similar results to static panel data estimation results. According to Table 4, REN, CO2 emissions, and GOV similarly have a reducing effect on FFS. However, per capita income has an increasing effect on FFS. These findings show that REN, CO2 emissions, and GOV offer a solution to the political, economic, and environmental problems of FFS.

Table 4. Dynamic panel estimation

Explanatory variables	System-GMM	Difference-GMM
FFS(-1)	0.491	0.304
	(0.038)	(0.317)
	[0.236]	[0.304]
REN	-0.159	-0.206
	(0.060)	(0.055)
	[0.084]	[0.107]
CO2	-0.276	-0.339
	(0.087)	(0.090)
	[0.161]	[0.200]
GOV	-0.458	-0.556
	(0.088)	(0.040)
	[.0268]	[0.271]
GDP	0.896	1.145
	(0.023)	(0.011)
	[0.394]	[0.449]
Constant	-4.425	-5.480
	(0.049)	(0.026)
	[2.246]	[2.463]
Instruments	91	70
AR(1)	-1.05	-0.97
	(0.291)	(0.332)
AR(2)	0.46	0.09
	(0.643)	(0.926)
Hansen	41.26	39.89
	(1.000)	(0.992)

( ) and [ ] indicate the probability and standard error, respectively.

The reliability of the results obtained from the Difference-GMM and System GMM estimators is tested using AR(1) and AR(2) statistics (whether there is first and second-order autocorrelation) and Hansen-J statistics (whether the instrumental variables are valid). The results obtained from these tests indicate that there is no second-order autocorrelation in the estimation models and that

the instrumental variables are valid. These results confirm the validity of the model specification and the instrument variables used to address the endogeneity problem [29]. Therefore, passing these tests means that the study's empirical findings are robust and can be used to inform policy or academic arguments.

The results provide evidence for four significant outcomes. First, we support the view that REN is effective in reducing FFS. Our findings are consistent with the results of Beaton and Lonton [5]. They found that technology-focused policies in Indonesia, which encouraged consumers to use alternative stoves powered by cleaner liquefied petroleum gas, contributed to the reduction of kerosene subsidies. Similarly, Zastempowski [45] found that innovations replacing fossil fuel energy with REN sources in 13 European Union countries yielded positive results. At this point, the effects of FFS can be reduced by expanding incentives and support for clean energy production and technologies. Therefore, REN policies can reduce the legitimacy of FFS [34]. At the same time, within the scope of SDGs, investments in clean energy can play an important role in improving air quality by reducing FFS and limiting fossil fuel use. Antimiani et al. [1] have stated that support measures for clean energy technologies are crucial for the decarbonization process. Droste et al. [16] have stated that the adoption of REN can overcome dependence on fossil fuel-based economic systems. This finding supports the hypothesis that REN has a reducing effect on FFS (H1).

Second, we show that reducing FFS contributes to lowering CO2 emissions. Empirical evidence shows that increases in FFS worsen environmental quality [35], but that removing these subsidies or reforming them improves environmental quality [4, 10]. Furthermore, the impact of environmental policies on fuel subsidies is an important but insufficiently studied topic. In this sense, serious decisions taken at the international level to reduce greenhouse gas concentrations may lead to pressure for reform of FFS. In this regard, for example, the IEA [22] "Net Zero by 2050" report states that direct emission reduction regulations are needed in the transportation sector, including regulations to reduce sales of internal combustion engine vehicles and increase the use of liquid biofuels and synthetic fuels in aviation and shipping, as well as measures to ensure that low oil prices do not lead to increased consumption. Again, Tavakolian et al. [38] showed that CO2 emissions are effective in the payment of gasoline subsidies.

Third, we show that GOV contributes to the reduction of FFS. Our findings are consistent with expectations and align with the results of Foo et al. [17]. They demonstrated that GOV has a reducing effect on FFS. According to the World Bank [43], GOV reflects how well public services are delivered, the degree of independence from political pressures, the effectiveness of policy design and implementation, and the reliability of the government's commitment to its policies. Interest groups, the political importance of the energy sector, the perceived importance of subsidies for social protection, and governments' risk aversion have hindered FFS reform in many countries [7]. Therefore, reducing the political influence of subsidy-friendly groups may help overcome entrenched dependencies on fossil fuel-based economic systems [16]. Consequently, government effectiveness and not giving in to interest groups can ensure the independence of FFS from political pressures in countries. The research confirms the hypothesis that GOV negatively affects FFS (H2).

Finally, we show that economic growth contributes to FFS. This conclusion is further supported by Van Beers and Strand [41]. They argued that higher levels of gross domestic product per capita lead to higher fuel prices. As economic growth increases, economies tend to show an increase in energy demand accordingly. Therefore, while meeting increasing energy demands, countries can increase the share of clean energy sources in total energy demand rather than fossil fuels. Thus, the negative effects of FFS on SDGs are minimized.

7. CONCLUSION

The effects of FFS on macroeconomic performance, the environment, and sustainable development have been frequently discussed in the literature. However, the impact of factors contributing to the increase or reduction of FFS remains an open topic for debate in literature. Therefore, this study examined how REN, GOV, CO_2 emissions, and growth affect FFS using baseline regressions and dynamic GMM estimators. The findings show that REN, GOV, and CO_2 emissions play an important role in reducing FFS, but GDP has an increasing effect. The findings from this study support the theory proposed by Droste et al. [16].

The implementation of stable and balanced government policies tends to reduce fossil fuel subsidies. Redirecting these subsidies toward renewable energy investments can generate dual benefits by both promoting sustainable development and supporting long-term energy transition goals. Consequently, policymakers are expected to make well-informed and carefully considered decisions that prioritize policy stability and sustainability. Governments should prioritize the

abolition of fossil fuel subsidies and reallocate such funds towards public welfare-enhancing investments, a strategy that serves the broader societal interest rather than capitulating to the rent-seeking demands of entrenched lobbying groups.

More importantly, we have shown that renewable energy policies, serious environmental policies, and good government effectiveness are vital in achieving results consistent with SDGs by reducing FFS. Future studies can compare the impact of FFS in developed and developing countries, considering renewable energy and other governance indicators. Similarly, this comparison can be made by considering low-, middle-, and high-income countries.

NOMENCLATURE

APEC	Asia-Pacific Economic Cooperation
D-K	Driscoll-Kraay
ESG	Environmental, Social, Governance
FFS	Fossil Fuel Subsidies
GDP	Gross Domestic Product
GMM	Generalized Method of Moments
GOV	Government Effectiveness
IEA	International Energy Agency
OECD	Organisation for Economic Co-operation and Development
OLS	Ordinary Least Squares
PCSE	Panel Corrected Standard Errors
REN	Renewable Energy
SDGs	Sustainable Development Goals
UN	United Nations

ACKNOWLEDGMENT

DECLARATION OF ETHICAL STANDARDS

The author of the paper submitted declare that nothing which is necessary for achieving the paper requires ethical committee and/or legal-special permissions.

CONTRIBUTION OF THE AUTHORS

Doğan Barak: Writing, Investigation, Analysis, Methodology, Conceptualization. Methodology, Editing, Supervision, Resources.

CONFLICT OF INTEREST

There is no conflict of interest in this study.

Appendix 1. List of countries

Countries		
Argentina	Georgia	Netherlands
Australia	Germany	New Zealand
Austria	Greece	Norway
Azerbaijan	Hungary	Poland
Belgium	India	Portugal
Brazil	Indonesia	Slovak
Canada	Ireland	Slovenia
Chile	Israil	South Africa
China	Italy	Spain
Colombia	Japan	Sweden
Costa Rika	Latvia	Switzerland
Denmark	Lithuania	Türkiye
Estonia	Luxemburg	UK
Finland	Mexico	USA
France	Moldova	Czechia

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