Impact of FDI and Stock Market Expansion on Clean Energy: A Case of Selected Countries

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Abstract

The ongoing challenge of global warming fundamentally alters Earth's climate patterns, primarily due to the escalating levels of carbon emissions. This environmental perturbation necessitates a critical shift from conventional fossil fuel energy sources to cleaner alternatives. In this study, we undertake an extensive examination of the impact of stock market expansion and FDI on clean energy adoption within different income strata, encompassing high-income, middle-class income, and lower-class income countries. Our comprehensive analysis employs advanced econometric methodologies, specifically the approaches of Dynamic Ordinary Least Squares (DOLS) and Fully Modified Ordinary Least Squares (FMOLS). The results reveal intricate relationships among the variables of interest. Notably, CO2 emissions, FDI inflow, and trade openness exhibit statistically significant negative associations with clean energy adoption, while energy consumption and stock market growth display positive correlations. This study offers pertinent policy implications. Most notably, it underscores the pivotal role of stock market growth in facilitating clean energy adoption. Governments are encouraged to leverage stock markets as a viable avenue for securing more money for clean energy ventures by listing pure energy stocks on stock exchanges. Furthermore, governments may explore extending tax incentives to encourage investment in clean energy firms.

Keywords: Clean Energy Consumption, CO2 Emission, FDI, and Stock Market Growth.

Introduction

Energy is paramount in contemporary economies as a linchpin for economic growth. Amid the specter of climate change, driven by escalating emissions, the interdependence of energy consumption and environmental security becomes increasingly evident. In this context, the imperative of transitioning away from nonrenewable resources gains prominence, particularly against the backdrop of mounting global warming concerns and environmental degradation, which reverberate across both developed and developing nations.

While extant literature has extensively scrutinized the nexus of energy usage, financial development, economic expansion, FDI, and stock market growth, it now pivots towards a salient focus on clean energy adoption. Clean energy, with its potential to mitigate CO2 emissions and meet surging energy demands, takes center stage as a preferable alternative to conventional sources. Research by Zandi and Haseeb (2019) underscores the adverse and notable effects on CO2 emissions from using clean energy and economic growth. Consequently, advanced and emerging economies are pivoting their strategies towards clean energy development and production.

Relying on less environmentally harmful resources such as hydropower, renewables, and natural gas can potentially ameliorate environmental quality. FDI's ecological impact is context-dependent, with the potential to enhance or exacerbate environmental performance, as

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argued by Dong, et al. (2019). By initiating ecologically sustainable projects employing renewable energy technologies, most economies can mitigate the environmental consequences of energy consumption. The infusion of FDI inflows is pivotal in supporting clean energy projects, concurrently satiating energy demands while reducing CO_2 emissions. The arrival of foreign investors in developing nations typically accompanies the introduction of advanced machinery and technology, facilitating increased production with reduced energy consumption. Trade development is integral in fostering clean energy adoption, as expounded by Sadorsky (2012). International trade spurs economic activity and heightens energy demand, necessitating the importation of energy-efficient technologies by developing countries. Trade liberalization also expedites access to cutting-edge technologies. The progressive evolution of stock markets can foster investments in clean energy projects through capital allocation. These investments usher in advanced technology and efficient machinery, ultimately diminishing CO_2 emissions, as supported by Ji and Zhang (2019). The financial sector's role in promoting renewable energy growth is undeniably pivotal.

The increasing levels of carbon emissions have contributed to catastrophic environmental degradation, particularly the relentless ascent of environmental pollution. While carbon emissions remain a significant concern, clean energy adoption emerges as a critical focal point in the 21st century. Numerous studies have scrutinized the association link between the use of clean energy, FDI, stock market expansion, CO_2 emissions, and economic growth. However, only some have delved into the interplay between clean energy utilization, FDI, stock market development, and trade openness. It is pertinent to acknowledge that the selection process, data periods, number of observations, and econometric methodologies can lead to varying empirical results across nations. Notably, prior research has yet to comprehensively examine the combined influence of trade openness, FDI, and stock market expansion on the uptake of clean energy in high-income, higher-middle-income, and lower-middle-income nations.

Understanding the multifaceted factors influencing clean energy adoption is imperative. Such knowledge aids in identifying key drivers for the growth of clean energy use and formulating practical policy recommendations. This study aspires to bridge this gap and offer valuable insights for shaping policies that combat carbon emissions and advocate for sustainable, environmentally friendly economic growth. The study seeks to accomplish the following objectives:

1. Investigate the impact of FDI inflows on the use of clean energy.
2. Analyze the influence of stock market growth on clean energy utilization.
3. Examine the effect of trade openness on clean energy adoption.

The key to this dynamic is clean energy. It lays out a clear road ahead, combining the demands of economic growth with the needs of a greener, more sustainable future. As a result, both established and emerging economies are investing significantly in the discovery and manufacture of renewable energy solutions.

This study makes an ambitious step toward comprehending the complexity of the clean energy paradigm shift. It goes beyond the previous research to investigate how numerous factors, including FDI, stock market development, and trade openness, interact with and impact the adoption of sustainable energy solutions. It dives into the complex linkages that drive the move to greener energy sources. We aim to uncover the key drivers, challenges, and policy imperatives that shape the adoption of clean energy in different countries and income brackets. This study fills a significant gap in the literature by examining how trade openness, stock market development, and FDI all impact the usage of renewable energy in high-income, upper-middle-class, and lower-middle-class countries (Zandi & Haseeb, 2019). It provides essential insights for stakeholders and policymakers looking to manage the complexity of clean energy adoption, confront environmental pollution, and encourage environmentally friendly and sustainable economic growth, leading to economic prosperity.

The following is the paper's layout: Section 2 comprehensively reviews the research on clean energy adoption and its links to FDI, stock market growth, carbon emissions, and economic growth (Dong et al., 2019; Ji & Zhang, 2019; Sadorsky, 2012). Section 3 describes the study methodology and the data sources used in the analysis. The empirical findings are presented in Section 4, and the article finishes in Section 5, with a summary of the study's essential conclusions and policy suggestions that represent the urgency and relevance of our search for a greener, more sustainable future.

Review of the Literature

Economists are grappling with a crucial issue: reducing the environmental effect of economic expansion. Economic expansion is a common objective for many countries, particularly those in the developing world. Among the several ways to reach this goal, FDI (FDI) is an appealing choice. FDI has been recognized for its potential to bolster economic growth by increasing output, making it a substantial source of external funding (Weimin et al., 2021). Recent academic studies have thoroughly examined the phenomenon of FDI and its consequences, particularly in the context of environmental impact.

The existing body of research encompasses numerous studies investigating the intricate connection between energy use, stock market expansion, and FDI. These studies have produced a mosaic of results, often revealing divergent perspectives. For instance, Caetano et al. (2022) suggest that FDI may not necessarily lead to the relocation of polluting industries; instead, it may inadvertently contribute to increased pollution. However, investment directed towards the electricity sector could offer a means to disentangle economic growth from environmental degradation. Shahbaz et al. (2021) affirm that financial development is positively associated with adopting renewable energy sources, underscoring the importance of FDI in driving demand for renewable energy. Consequently, this interplay between economic growth, fossil fuel consumption, and renewable energy forms a complex nexus.

Mohsin et al. (2022) offer a nuanced perspective on this interplay by demonstrating that Gross Domestic Product (GDP) Granger causes CO2 emissions, while energy consumption and FDI Granger cause CO2 emissions. This analysis reveals a significant negative long-term relationship between CO2 emissions and GDP, alongside a positive short-term relationship.

The proposition that attracting FDI into a country's renewable energy sector can serve as a bridge to a cleaner energy transition has generated debate (Murshed et al., 2021). Habiba et al. (2021) contribute to this discourse by confirming that the development of stock markets reduces carbon emissions, particularly in developed countries. However, the index of financial institution development is found to increase carbon emissions. Adopting renewable energy sources is observed to have a mitigating effect on environmental degradation across various panels. Notably, FDI emerges as a catalyst for improving environmental quality, particularly in developing economies.

Fan and Hao (2020) argue that FDI is crucial in developing renewable energy projects, often necessitating substantial financial and technological resources. Caglar (2020) reinforces this perspective by highlighting that FDI increases renewable energy consumption. This increase indicates a shift towards enhanced energy consumption from renewable and nonrenewable sources.

However, only some studies present a consistent picture. Yilanci et al. (2019) discovered that FDI and Russia's use of clean energy were negatively correlated. It suggests that South Africa's adoption of clean energy is negatively impacted by trade openness (Kilicarslan, 2019). Furthermore, according to Kilicarslan (2019), FDI negatively impacts the generation of renewable energy consumption.

The relationship between FDI and energy consumption is not solely dependent on the income level of regions. Dong, Shao, and Zhang (2019) contend that there is no income disparity effect;

in other words, there is no clear evidence to support that FDI inflow into low and middle-income provinces leads to increased energy consumption, while the inflow into high-income provinces results in energy savings. The findings of their study suggest a variation in the direction of FDI spillovers across different provinces, further emphasizing the complex interplay at work. The results underscore the value of reasonable labor mobility in promoting energy-saving FDI spillovers.

Carbon emissions and FDI, according to Sbia et al. (2014), have a detrimental influence on demand for renewable energy. Doytch and Narayan (2015), on the other hand, discovered that FDI lowers nonrenewable energy consumption in the industrial sector while raising demand for renewable energy. Marton and Hagert (2017) make an intriguing discovery, indicating that while FDI initially reduces renewable energy usage, it eventually adds to a higher percentage of renewable energy consumption in the long run.

Several scholars have investigated the relationship between financial progress and energy usage. Charfeddine and Kahia (2019) and Anton and Nucu (2019), for example, discovered that financial development has a favorable and considerable influence on energy usage. Ji and Zhang (2019) underline the financial sector's critical role in pushing the rise of renewable energy in China. This discovery is consistent with the features of developing sector development, which is frequently characterized by risk and dependence on equity rather than debt funding. Furthermore, Eren et al. (2019) discovered a long-run link in the Indian economy between renewable energy usage and its drivers. They also identified a one-way causality between financial development, renewable energy consumption, and economic growth.

According to Rohan (2017), financial capital is a driving factor behind the shift to sustainable renewable energy sources and, as a result, contributes to an increase in the use of renewable energy. In contrast, Yazdi and Beygi (2017) discovered that financial development and renewable energy usage have a neutral effect. Burakov and Freidin (2017) investigated the long-run relationship between economic growth, renewable energy usage, and financial development. Their causality study revealed a one-way relationship between renewable energy usage and financial progress, but not vice versa. Kim and Park's (2016) study offer credence to the idea that the financial sector is critical to the growth of the renewable energy industry and emphasizes the relevance of renewable energy technology in decreasing carbon emissions. Wu and Broadstock's (2015) empirical studies indicated that institutional strength and financial growth had a positive influence on renewable energy usage.

These studies underscore the intricacies of the relationship between economic growth, FDI, financial development, and the adoption of clean and renewable energy sources. Their findings reveal a mosaic of outcomes, necessitating further exploration and nuanced policy considerations.

Zandi and Haseeb (2019) have further contributed to this exploration by confirming long-run associations among all the variables under scrutiny. Their results, obtained using (FMOLS) and Dynamic Ordinary Least Squares (DOLS), highlight an important insight: for every unit increase in green energy consumption, $CO2$ emissions are decreased by a large margin. Furthermore, the evidence confirms that economic development and green energy use have a negative and considerable influence on $CO2$ emissions.

The complicated dynamics of this link extend to heterogeneous panel causality tests, which find that in Sub-Saharan African nations, there is a bi-directional causal relationship between green energy usage, economic growth, and environmental deterioration. Cai et al. (2018) discovered no association between real GDP per capita, clean energy use, and $CO2$ emissions in nations such as Canada, France, Italy, the United States, and the United Kingdom. However, co-integration is determined in Japan and Germany when $CO2$ emissions and real GDP per capita are used as dependent variables. The Granger causality test shows that renewable energy usage increases real GDP per capita in Canada, Germany, and the United States. The causation in Germany is from CO2 emissions to clean energy use, but the link between the two in the United States is unidirectional.

Paramati et al. (2016) have significantly contributed to this discourse by demonstrating the positive impact of economic output, FDI inflows, and stock market developments on clean energy utilization. In contrast, they find that both CO2 radiation and energy consumption exert a negative influence on the adoption of clean energy sources. The research reveals energy consumption and carbon emissions, each resulting in a 1% reduction in clean energy utilization. This insight reinforces the intricate relationship between economic and environmental factors, emphasizing the need for nuanced and comprehensive policy measures.

In summary, these studies provide a rich tapestry of insights into the multifaceted relationship between economic growth, FDI, financial development, and the adoption of clean and renewable energy sources. The results are diverse and, at times, paradoxical, underscoring the complexity of this interplay. As a result, continued research is critical for guiding policy formation and making decisions in the context of long-term economic development and environmental preservation.

Theoretical Framework and Empirical Model

This study investigates the impact of FDI and stock growth in the market on the adoption of clean energy in three unique income brackets: high-income, higher-middle-income, and lower-middle-income nations. FDI has long been recognized as a pivotal conduit for financial resources and technology transfer across nations. Notably, it plays a significant role in catalyzing the adoption of clean energy solutions, thereby aligning with the imperatives of environmental sustainability. FDI inflows into renewable energy projects are of particular significance, catalyzing meeting growing energy demands while curbing the perils of CO2 emissions.

FDI channels investment and enhances credit availability, thus bolstering economic output by delivering both scale and efficiency benefits. Furthermore, FDI is instrumental in improving energy efficiency and facilitating the transition to renewable energy technologies, ultimately contributing to reducing carbon emissions.

In parallel, the growth of stock markets assumes a pivotal role in shaping the investment climate and fostering an environment conducive to investors and businesses. Such growth injects vitality into an economy, resulting in increased energy demand. The expansion of stock markets not only attracts investors but also encourages the funding of green energy ventures. This capital infusion translates into deploying modern equipment and efficient machinery, diminishing CO2 emissions.

Trade liberalization, another vital component, simplifies the importation of advanced technologies that enhance productivity and reduce energy consumption. It is of paramount importance, given the substantial energy dependence of both production and transportation operations.

In light of the preceding discussion and the research objectives, the benchmark model equation can be articulated as follows:

$$CEC_{it}=f\left(Output_{it}, CO2_{it}, EC_{it}, FDI_{it}, S_{it}, IO_{it}, TO_{it}, V_i\right) \quad (1)$$

CEC, Output, CO2, EC, FDI, S, IO, and TO stand for clean energy consumption, economic output, carbon dioxide emissions, energy consumption, FDI, stock market growth, industrial output, and trade openness, respectively. Vi denotes the fixed influence of a single country. Similarly, nations are represented by the subscript i (i=1, 2...N), and time is described by the subscript t (t=1, 2,....,T).

The stochastic arrangement of equation (1) can be written as:

$$CEC_{it}= \alpha_o+\alpha_1 OP_{it}+\alpha_2 CO2_{it}+\alpha_3 EC_{it}+\alpha_4 FDI_{it}+\alpha_5 S_{it}+\alpha_6 IO_{it}+\alpha_7 TO_{it}+\varepsilon_{it} \quad (2)$$

To estimate the above model, first we construct the variables used in the model. Description of variables are as follow:

Table 1 Variable Description and Sources

Symbol	Definition	Source
CEC	Clean energy use as percentage of total energy use	WDI
OP	Output in current US dollars	WDI
CO2	Carbon dioxide emission in metric tonnes	WDI
EC	Energy consumption in kilogram of oil equivalent	WDI
FDI	FDI net inflow in current US dollar	WDI
S	Stock market growth in current US dollars	WDI
IO	Industrial output sector output in current US dollars	WDI
TO	Trade openness in current US dollars	WDI

Note: World Development Indicators (WDI) is the prime World Bank collection of development indicators.

Clean Energy Consumption (CEC) encompasses various sources, including hydropower, nuclear power, geothermal power, and solar power. It represents the proportion of alternative and nuclear energy in the total energy consumed. Gross Domestic Product (GDP) is quantified in current US dollars, and per capita GDP is determined by dividing the GDP values by the total population of the respective country. Carbon dioxide emissions (CO2) are from gas flaring and using solid, liquid, and gaseous fuels. These emissions are measured in metric tons per person and are used to assess environmental impact. Energy consumption (EC) refers to the usage of primary energy before its transformation into other end-use fuels. It is computed as indigenous production plus imports and stock adjustments minus exports and fuels delivered to ships and planes participating in global transport expressed as a kilogram of oil or its equivalent per person.

FDI is the total of equity capital, earnings reinvestment, and other long-term and short-term capital. This dataset divides net foreign investor inflows into the reporting economy by Gross Domestic Product (GDP). Per capita FDI is derived by dividing this value by the entire population of the nation. Stock market growth (stocks) is evaluated based on the market capitalization of listed domestic companies, derived by multiplying the share price by the number of outstanding shares (inclusive of various classes).

Excluded from this calculation are investment trusts, unit trusts, and entities primarily holding shares of other publicly traded companies. Figures represent year-end values converted into US dollars using year-end foreign exchange rates. Per capita stock market growth is determined by dividing this by the nation's overall population. Trade Openness (TO) is assessed by aggregating imports and exports and dividing the total by a nation's GDP. Both imports and exports of goods and services are denominated in current US dollars, with the GDP also being measured using the current US dollar exchange rate. To arrive at trade openness per capita, the result is divided by a country's total population.

Our analysis is based on annual data from 27 countries, including high-income, upper-middle-income, and lower-middle-income nations, from 1995 to 2014. The dataset encompasses vital components such as clean energy output and consumption, FDI inflows, stock market growth, and industrial production, with data from the World Development Indicators (WDI).

To facilitate an empirical investigation, it is imperative to standardize and homogenize the data sequences. This normalization process involves converting the data into natural logarithms to address distributional characteristics effectively. As indicated by Shahbaz et al. (2012), using a log-linear configuration enhances result consistency and accuracy. Prior research (Alam et al., 2017; Bhattacharya et al., 2016, 2017; and Paramati et al., 2016) serves as the basis for transforming all variables into natural logarithms. The following log-linear function is employed:

$$\ln CEC_{it} = \beta_o + \beta_1 OP_{it} + \beta_2 CO2_{it} + \beta_3 EC_{it} + \beta_4 FDI_{it} + \beta_5 S_{it} + \beta_6 IO_{it} + \beta_7 TO_{it} + e_{it} \quad (3)$$

Results and Discussion

Descriptive Analysis

In the initial phase of our study, we conducted a comprehensive descriptive analysis of our dataset. To commence, we visually depicted the clean energy consumption (CEC) variable for each of the 27 countries under investigation. Subsequently, we created graphical representations that juxtaposed CO2 emissions, FDI per capita, and stock market development against the other pivotal variables within the scope of our study.

Table 2 provides a concise summary of the statistical characteristics of the 27 countries, categorizing them into high-income, upper-middle-income, and lower-middle-income brackets. Notably, this table showcases a substantial disparity in per-capita income levels across the nations, with Austria reporting the highest income at 38,036.29 US dollars and Bangladesh reporting the lowest at 582.0757 US dollars. Regarding per-capita CO2 emissions, the range extends from 0.206 metric tons in Zambia to 10.94 metric tons in the Netherlands. Clean energy consumption exhibits a similarly diverse range, from 0.219 percent of total energy utilization in Tunisia to 45.09 percent in France. These variations in pure energy consumption are primarily attributable to the presence of advanced technologies and the influence of national policies.

Per-capita energy consumption also exhibits substantial discrepancies among the countries. Bangladesh records the lowest mean per-capita energy consumption at 172.60 kilograms of oil equivalent, while France reports the highest at 4,074.29 kilograms. Regarding per-capita FDI inflow, the Netherlands secures the top position with an average of $9,608.53, whereas Bangladesh occupies the opposite end of the spectrum with the lowest FDI inflow at $5.10. Switzerland emerges as the leader in per-capita stock market growth, boasting a significant figure of 119,826.6 US dollars, while Ghana ranks at the bottom with a mere 69.88 US dollars. The variation is equally pronounced regarding industrial production per person, with Japan registering the highest at 11,642.54 US dollars and Kenya reporting the lowest at 118.76 US dollars. The metric for trade openness per capita follows a similar pattern, ranging from an average of 30,496.92 US dollars in Switzerland to 137.35 US dollars in Bangladesh.

Table 2 Summary statistics of high, upper middle and lower middle-income countries, 1995-2014

Summary Statistics: Mean by Country

Country	GDPPC	CO2EPC	ECPC	CEC	FDIPC	SMGPC	IOPC	TOPC
Argentina	8089.885	4.1513	1760.87	6.3502	203.18	1177.84	2112.37	1256.68
Austria	38036.29	8.0236	3817.15	10.5410	1408.68	9933.97	10240.15	18020.75
Bangladesh	582.07	0.3047	172.60	0.2370	5.10	94.04	141.11	137.35
Bulgaria	4301.92	6.1194	2500.18	24.0725	388.48	762.90	1038.13	2758.01
Croatia	9823.35	4.6428	2061.54	7.1770	427.03	3901.63	2337.55	4410.85
France	33522.51	5.7450	4074.29	45.0969	677.94	24232.12	6521.25	9503.97
Germany	35416.98	9.8028	4050.25	13.4573	692.87	15295.14	9682.11	12324.72
Ghana	859.09	0.3820	323.20	6.2182	48.95	69.88	220.01	424.52
Indonesia	1786.17	1.5902	775.31	0.7073	30.42	666.63	793.47	493.76
Iran	3829.53	6.5351	2332.22	0.4779	27.82	796.36	1692.63	839.96
Japan	38497.88	9.5025	3890.71	14.1363	63.34	27113.79	11642.54	5021.60

Kenya	677.71	0.2789	445.71	1.7904	7.75	174.72	118.76	244.08
Malaysia	6470.61	6.5529	2379.15	0.8905	230.12	9544.86	2754.64	5454.39
Mexico	7924.77	4.1292	1571.87	3.0017	208.22	2374.53	2625.23	2363.96
Namibia	3605.25	1.1978	668.25	16.8832	198.89	355.62	1001.05	2177.19
Netherlands	40415.33	10.9482	4819.47	2.0811	9608.53	36202.43	8447.01	25683.63
New Zealand	26072.77	7.9813	4228	13.8919	384.19	9185.54	5488.72	7935.48
Nigeria	1437.16	0.5708	735.54	0.3598	26.61	192.67	379.82	249.16
Pakistan	761.76	0.8176	460.58	3.0714	10.23	174.23	161.56	156.56
Philippines	1555.24	0.8960	464.02	3.1634	22.47	980.56	505.86	686.83
Portugal	17471.51	5.3999	2265.42	5.4472	653.25	6266.61	3763.55	6768.81
South Africa	4930.85	8.9092	2613.69	2.7220	78.04	10388.28	1371.20	1511.11
Switzerland	58691.38	5.3513	3446.30	38.5194	2228.87	119826.6	15364.54	30496.92
Thailand	3531.63	3.5805	1460.75	0.6923	103.99	2385.98	1340.34	2275.76
Tunisia	3176.01	2.2003	822.45	0.2193	97.02	491.23	884.42	1688.85
Turkey	7145.51	3.6541	1299.31	4.7412	113.10	1968.01	1909.87	2023.05
Zambia	901.37	0.2060	614.58	8.2897	53.61	135.26	277.92	334.00
Total	13315.36	4.4249	2001.98	8.6939	666.62	10544.13	3437.62	5379.33

The essential statistics of the selected panel of high-income, upper-middle-income, and lower-middle-income countries are shown below in Table 3.

Table 3 Descriptive Statistics

Summarise: GDPPC, CO2EPC, ECPC, CEC, FDIPC, SMGPC, IOPC, and TOPC

Variable	Observations	Mean	Std. Deviation	Minimum	Maximum
GDPPC	540	13315.36	17110.99	258.471	88415.63
CO2EPC	540	4.4249	3.28614	0.1542709	11.9666
ECPC	540	2001.98	1424.62	135.9485	5085.886
CEC	540	8.6939	11.2144	0.049564	49.59042
FDIPC	540	666.62	2826.185	-3081.394	44806.74
SMGPC	540	10544.13	24821.84	0.6696301	190460.4
IOPC	540	3437.6	4280.113	44.16428	22953.42
TOPC	540	5379.33	8516.599	57.13815	51547.82

GDPPC, CO2EPC, ECPC, CEC, FDIPC, SMGPC, IOPC, and TOPC are GDP per capita, CO2 emission per capita, energy consumption per capita, clean energy consumption per capita, FDI per capita, stock market growth per capita, industrial output per capita, and trade openness per capita, respectively, as shown in Table 3.

According to Table 3, GDPPC has an average value of 13315.36, a minimum value of 258.47, and a maximum value of 88415.63. CO2EPC has a mean value of 4.4249, with a low of 0.1542 and a high of 11.966. The CEC mean value of 8.693, with a minimum value of 0.0495 and a maximum value of 49.5904, is noteworthy. Furthermore, the ECPC mean value is 2001.98, with a minimum of 135.948 and a maximum of 5085.886. The FDIPC has a mean value of 666.62, a minimum value of -3081.39, and a maximum value of 44806.7. SMGPC has a mean value of 10544.13, with a minimum of 0.6696 and a maximum of 190460.4. The IOPC has a mean value of 3437.627, with a minimum of 44.164 and a maximum of 22953.42. Finally, the average TOPC value is 5379.336, with a low of 57.138 and a high of 51547.82. All the variables that were chosen had positive standard deviations.

Table 4 Unconditional Correlations

Correlation: GDPPC, CO2EPC, ECPC, CEC, FDIPC, SMGPC, IOPC, and TOPC

	GDPPC	CO2EPC	ECPC	CEC	FDIPC	SMGPC	IOPC	TOPC
GDPPC	1							
CO2EPC	0.6337	1						
ECPC	0.7946	0.9313	1					
CEC	0.5864	0.2386	0.4860	1				
FDIPC	0.3876	0.2958	0.3361	0.0429	1			
SMGPC	0.7718	0.3228	0.4715	0.5759	0.3151	1		
IOPC	0.9795	0.6459	0.7747	0.5477	0.3236	0.7720	1	
TOPC	0.8993	0.5126	0.6565	0.4543	0.5392	0.8086	0.8569	1

Table 4 shows the unconditional correlation between the variables chosen. The findings showed that GDPPC exhibited a positive correlation with all the variables. The correlation between GDPPC IOPC and TOPC is exceptionally high, whereas it is the least correlated with FDIPC and CEC. Similarly, CO2EPC is positively correlated with all variables. It connects the most with ECPC and the least with CEC. ECPC also has a positive correlation with all of the variables. It correlates the most with IOPC and the least with FDIPC. Finally, CEC has a positive correlation with all other variables. According to the results of unconditional correlation, there is a positive correlation between all of the chosen variables.

The clean energy consumption share of global energy consumption in 27 high-income, upper-middle-income, and lower-middle-income countries is depicted in the graph in Figure 1. In Argentina, Bangladesh, Germany, and Kenya, the consumption of clean energy first rises and then falls over time. The nations trending upward are Austria, Bulgaria, Tunisia, Algeria, Algeria, France, Iran, Indonesia, Namibia, Netherlands, Pakistan, Portugal, Philippines, Turkey, and Switzerland. These findings show that these nations are attempting to minimize CO2 emissions while also meeting rising energy demand, as evidenced by an increase in the fraction of clean energy consumption in total energy consumption. Nonetheless, Ghana, Japan, and South Africa have diminishing clean energy consumption shares in actual energy use, indicating that these countries have yet to concentrate much on raising their clean energy consumption shares in total energy use. Malaysia, Mexico, New Zealand, Nigeria, Thailand, Turkey, and Zambia all had different outcomes.

Figure 1 Clean energy consumption percentage of total energy use

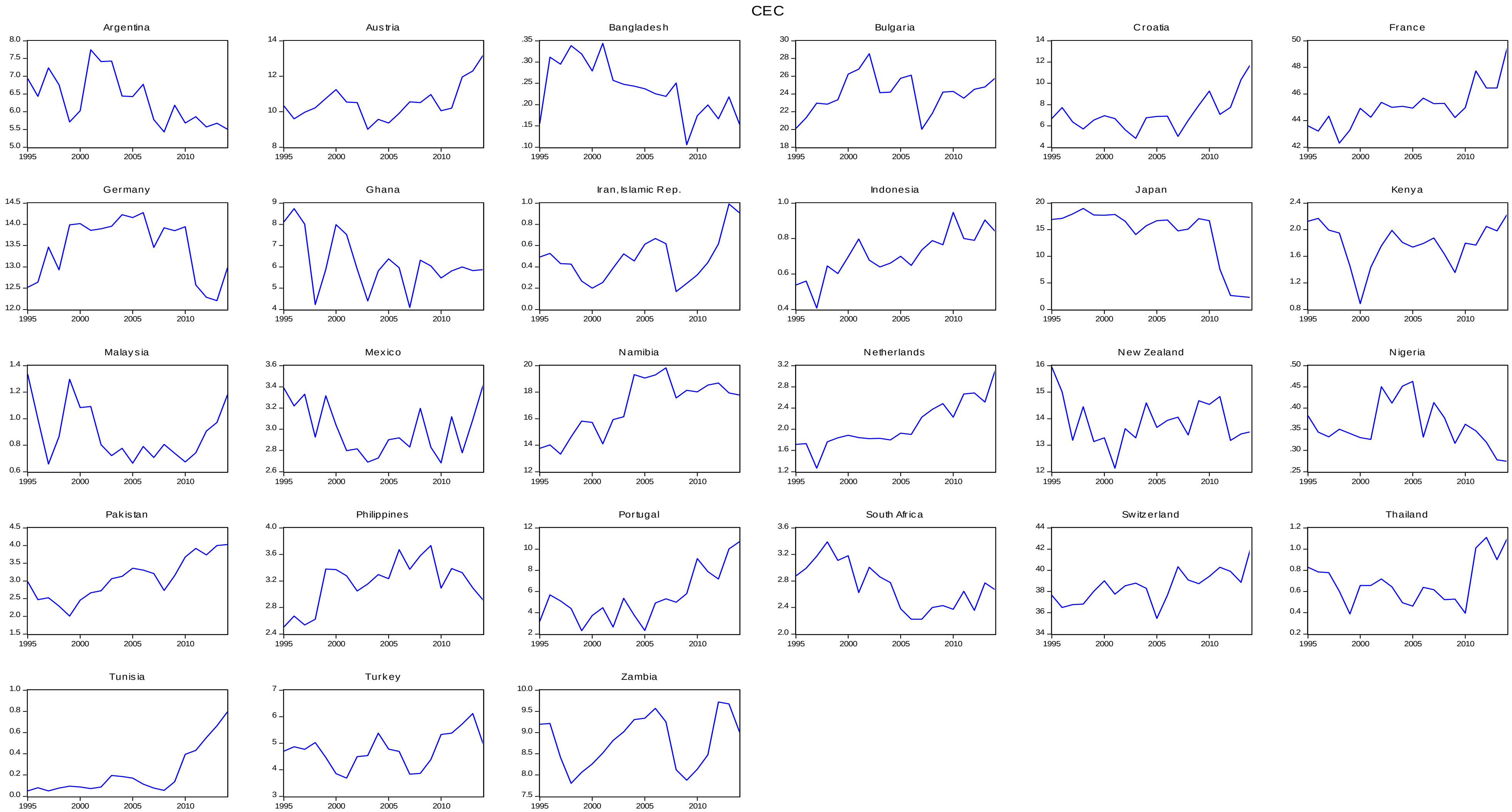
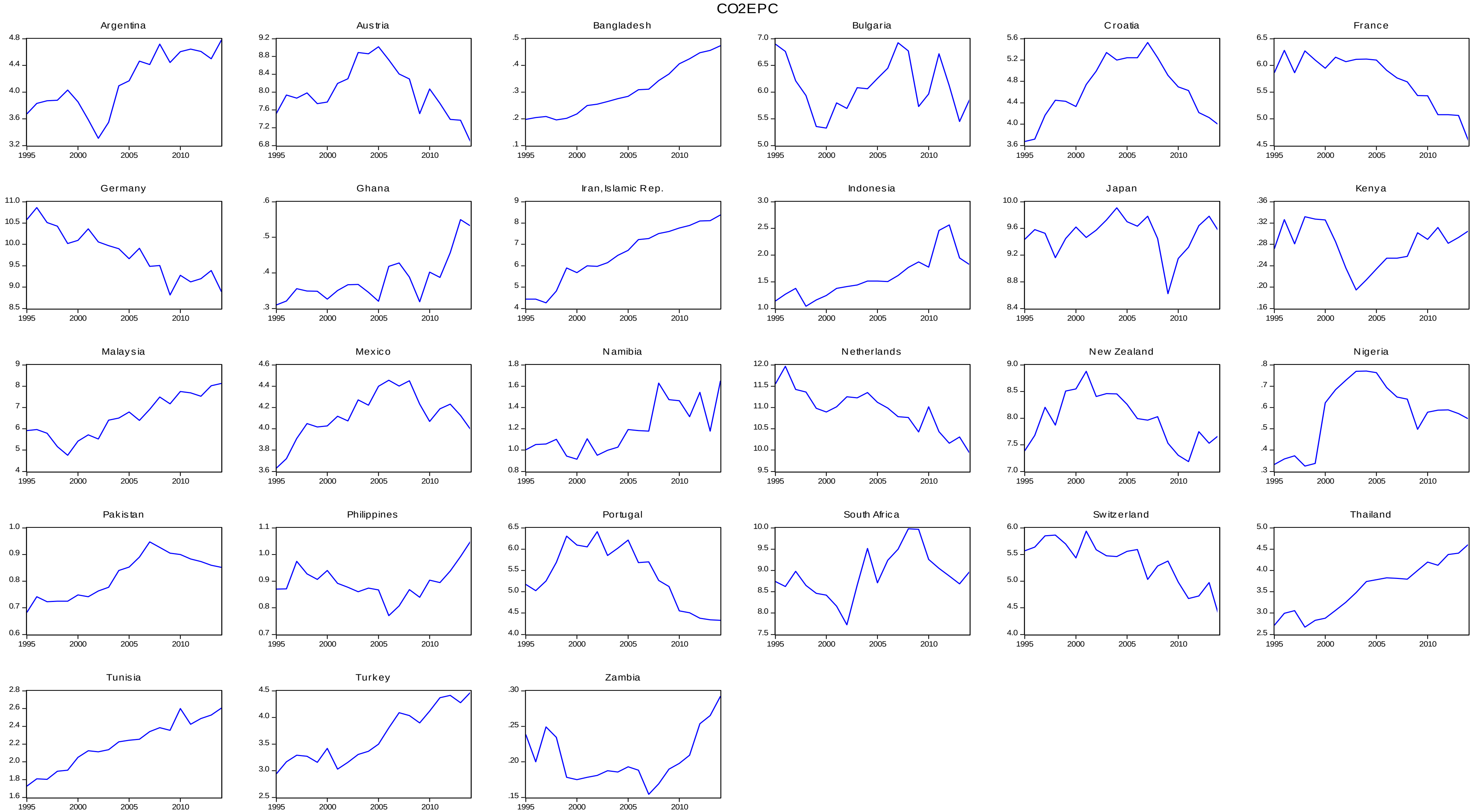


Figure 2 Carbon dioxide emission per capita



In 27 nations with a high income, a higher middle income, and a lower middle income, Figure 2 shows the metric tonnes of CO2 emissions per person. Bangladesh, Ghana, Iran, Indonesia, Pakistan, Philippines, Thailand, Tunisia, and Turkey were the countries with the greatest per capita CO2 emissions from 1995 to 2014. However, France, Germany, the Netherlands, and Switzerland had the lowest per capita CO2 emissions from 1995 to 2014. Argentina, Austria, Bulgaria, Croatia, Japan, Kenya, Mexico, New Zealand, Nigeria, Portugal, South Africa, and Zambia all have mixed results, according to the graph.

Regression Analysis

In this part, various econometric techniques were used to analyse and describe the statistical findings from our panel data set.

Panel unit root test results

Table 5 displays the findings of IM, Pesaran, and Shin (2003) for finding of unit root. The results demonstrate that all the variables are non-stationary at level and reject the null hypothesis of the test at significant level for all variables. The results validate the stationarity of all variables at the 1st difference, which shows that all of the variables are order one integrated, I (1).

Table 5 IPS Unit root test

Variable	IPS test at level	IPS test First Difference
CEC	-0.2939	-12.3585***
GDPPC	7.7870	-6.5413***
CO2PC	3.4659	-9.1307***
ECPC	4.2162	-8.1171***
FDIPC	-1.5013	-12.9296***
SMGPC	2.5895	-11.6464***
TOPC	6.2807	-11.0617***

Note: *** indicate rejection of the null hypothesis of the unit root at 1% significance level.

Panel co-integration test results

We use Kao (2003) and Pedroni (2004) panel co-integration tests to examine the long-run relationship between clean energy consumption, output, CO2 emissions, energy consumption, FDI, stock market development, and trade openness. The industrial output variable has dropped because of its high correlation with GDPPC. If there is a high correlation between the explanatory variables, it may create the problem of multicollinearity.

The Pedroni panel co-integration test results are shown in Table 6. The null hypothesis, according to most of this procedure, is rejected: co-integration is not accurate. In total, the null hypothesis is rejected by four out of the seven estimations. It means the variables have long-term correlations and move together in the long run.

Table 6 Results of Pedroni (Engle-Granger based) Panel Co-integration

Estimates	Statistic	Prob.
CEC= *f* (CEC+CO2EPC+ECPC+FDIPC+GDPPC+SMGPC+TOPC)		
Panel v-statistic	-4.479731	1.0000
Panel rho-statistic	2.645126	0.9959
Panel PP statistic	-23.56252	0.0000
Panel ADF statistic	-10.39094	0.0000
Alternative Hypothesis: Individual AR Coefficient		
Group rho-statistic	4.464366	1.0000
Group PP statistic	-24.88941	0.0000
Group ADF statistic	-10.25792	0.0000

Note: The null hypothesis of Pedroni (Engle-Granger based***)*** co-integration procedure is no co-integration.

Table 7 presents the results of the Kao panel co-integration test. The findings demonstrated that all variables are co-integrated, confirming the presence of a long run relationship between clean energy use, output, CO2 emissions, energy use, FDI inflow, stock market expansion, and trade openness.

Table 7 Results of Kao (Engle-Granger based) Panel Co-integration

Estimates	Statistics	Prob.
CEC= *f* (CEC+CO2EPC+ECPC+FDIPC+GDPPC+SMGPC+TOPC)		
Panel ADF-statistics	-16.6632	0.0000

Note: The null hypothesis of Kao residual co-integration panel co-integration procedure is no co-integration.

The Pedroni and Kao panel cointegration tests indicate the long-term relationship between all variables. The fully modified ordinary least squares (FMOLS) model can be used to identify a long-run relationship between the variables. Pedroni (2001a, 2001b) argued that inconsistent controls might influence the presence of sequential correlation and endogeneity concerns among the regressors. The FMOLS technique is used in this evaluation to address these difficulties. As a result, we employ FMOLS and DOLS methodologies to investigate the long-term correlations between clean energy usage, production, CO2 emissions, energy consumption, FDI inflows, stock market development, and trade openness in high-, upper-, and lower-income nations.

Panel Estimates of long-run elasticity's

This study examines the effects of stock market expansion and FDI (FDI) on the usage of renewable energy for a panel of 27 high-income, upper-middle-income, and lower-middle-income countries. We employed Fully Modified Ordinary Least Square (FMOLS) and Dynamic Ordinary Least Square (DOLS) after confirming that the variables are integrated into order one, I (1).

Table 8 Long-run Estimate using FMOLS and DOLS.

Variable	FMOLS			DOLS		
	Coefficient	t-statistics	probability	Coefficient	t-statistics	Probability
GDPPC	-9.4823	-0.8311	0.4063	0.000589	16.8322	0.0000
CO2EPC	-3.6741	-17.0011	0.0000	1.2201	3.7984	0.0002
ECPC	0.01326	27.4260	0.0000	-0.00943	-6.5825	0.0000
FDIPC	-0.00101	-5.6672	0.0000	-0.00373	-23.0793	0.0000
SMGPC	0.00090	11.3225	0.0000	0.00144	12.8307	0.0000
TOPC	-0.00201	-31.1357	0.0000	-0.00591	-15.0183	0.0000
R-Square		0.309957		0.93491		
Adjusted R-Square		0.303152		0.885532		

Table 8 represents the panel long-run (FMOLS) and (DOLS) results. The finding of FMOLS confirmed that all the variables are statistically significant at a one percent level except GDPPC. The results of FMOLS show that output does not have any significant impact on clean energy consumption. The findings of FMOLS revealed that CO2EPC, FDIPC, and TOPC have a negative and significant effect on pure energy consumption. The coefficient of CO2EPC indicates that per unit change in CO2EPC will reduce clean energy consumption by -3.6741 units.

Similarly, the coefficients of FDIPC and TOPC confirmed that per unit variation in FDIPC and TOPC decreases clean energy usage by -0.00101 and -0.00201 units, respectively. However, the findings of FMOLS confirmed that ECPC and SMGPC have a positive and statistically significant impact on clean energy consumption. The coefficients of ECPC and SMGPC revealed that per unit change in ECPC and SMGPC raise pure energy consumption by 0.01326 and 0.00090 units, respectively. Overall, the results of FMOLS confirmed CO2EPC and SMGPC are consistent with the results of Paramati et al. (2016). The results of the output, ECPC, and FDI contrast with Paramati et al. (2016).

Conclusion and Policy Recommendation

The purpose of this study was to examine the impact of FDI, stock market development, and industrial output on clean energy consumption from 1995 to 2014; data was collected in 27 nations classified as high-income, upper-middle-income, and lower-middle-income. Significantly, the FDI inflows, stock market development, and industrial output raised economic activities in the selected economies. This hike in economic activity would increase energy demand, and it would lead to emitting more CO2. Thus, to meet the increasing energy demand and to reduce CO2 emissions, clean energy consumption is therefore favored. Only by utilizing more clean energy and implementing cutting-edge (green) technologies will carbon emissions be reduced. Examining the effect of industrial sector output on renewable energy consumption is the goal of this study. Conversely, worldwide funding for sustainable energy projects has been rising over time. Thus, the impact of FDI inflows and stock market growth on the consumption of clean energy is also examined in this study.

The empirical findings of the study revealed a robust long-term relationship between clean energy use, production, CO2 emissions, energy consumption, FDI inflows, stock market expansion, and trade openness. According to the FMOLS findings, it has no apparent influence on the usage of renewable energy. The FMOLS findings revealed that trade openness, FDI inflows, and CO2 emissions all had a substantial and negative impact on the use of renewable energy. Nonetheless, the growth in the stock market and energy consumption benefits the usage of renewable energy. The DOLS results confirmed that every variable has a significant influence on the use of renewable energy. CO2 emissions and stock market growth benefit clean energy use in the DOLS results output. Conversely, trade openness, FDI inflows, and energy use have a detrimental effect on the use of clean energy.

In a nutshell, the findings revealed that stock market expansion and trade openness have a favorable impact on renewable energy usage. FDI inflows, on the other hand, have a negative influence on clean energy usage. According to the report, rising stock market values encourage using sustainable energy. The government may utilize stock exchanges to raise more funds for clean energy projects by listing pure energy equities on stock exchanges, and the government can also offer tax breaks to investors in clean energy enterprises.

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