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Revisiting the Relationship between Energy Price Fluctuations, Forestry, Environmental Governance, and Energy Transition on Carbon Emissions: Evidence from Indonesia

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ABSTRACT

This paper summarizes the role of energy price fluctuation, forestry, environmental governance, and energy transition on carbon emissions. Since, industrialization and population growth, both are the factors which according to literature are culprits of environmental pollution or sometimes benefits the environment, hence, the contradictory statement of scholars urges the authors to introduce these two variables as a control variable in proposed framework. To analyze the time series data in the time span of 1986-2019, the study used DARDL approach and from the results it has been revealed that energy price fluctuation, forestry, environmental governance, environmental governance, energy transition and population growth increases environmental protection by reducing harmful emission. Based on the results, an empirical baseline is provided to policy makers to strategize their agenda and promote the usage of renewable resources.

Keywords: Energy Prices Fluctuation, Environmental Governance, Energy Transition, Forestry, Environmental Governance
JEL Classifications: O13, E32, P31, Q23, H23

1. INTRODUCTION

Global warming and climate change is treated as the bigger challenge of 21st century. The reason is vast ratio of GHG emissions. Although, GHG emissions itself are harmful but amongst all carbon emissions are the deadliest and cause huge environmental destruction. It is predicted that the consequences will get bigger with the passage of time if not address timely. Hence, in present environment, there are two main issues which world is facing today; CO_2 reduction and enhancement of environmental quality. With the objective of 1.5°C, Indonesia also joined hands in 2016 and pledge to keep the temperature bar below 2°C. The government of Indonesia also pledged to achieve the goal of carbon neutrality by 2060 and reduce 41% GHG emissions by 2030 (Bai et al., 2022; Ibar-Alonso et al., 2022). In order to maintain the balance, such as rapid economic growth with less environmental damages, Indonesian government must address the dire challenges timely. Investigating the significance of factors that have an effect on emission reduction is an effective way to address these issue and also crucial subject in case of Indonesia as the country might receive help from such evidences to reduce emissions timely (Carriquiry et al., 2022; Chau et al., 2022).

Indonesia has 5th ranking at global level in terms of GDP ranking with the GDP of 3328 billion US dollars in the year 2020. The country witnessed highest GDP in Southeast Asia in the same year. Thus, it is imperative to identify whether economy of Indonesia is progressing in tandem with the improvement of environmental quality. Interestingly, fossil fuels which are

the cause of environmental destruction, fulfill energy need of Indonesia (Figures 1 and 2). With the exploitation of fossil fuels to produce electricity, the country is culprit to have the larger share of carbon emissions at global level (Rawtani et al., 2022). This implies the direct association of Indonesia's rapid economic growth and rising energy demand. Thus, the country shows a great concern to limit the emission due to this direct connection. Thus, in order to fulfill the ultimate goal, renewable energy utilization is necessary. Luckily, as shown in Figure 3, Indonesia has remarkable renewable resources and country' legal framework has been constructed to promote the use of renewable resources (Chien et al., 2022; Chien et al., 2023a).

Figure 1: Total electricity supply of Indonesia in 2018 (IEA, 2020)

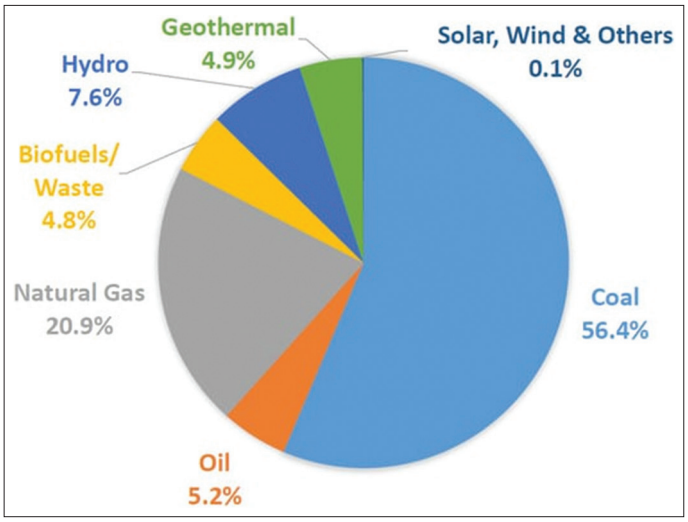
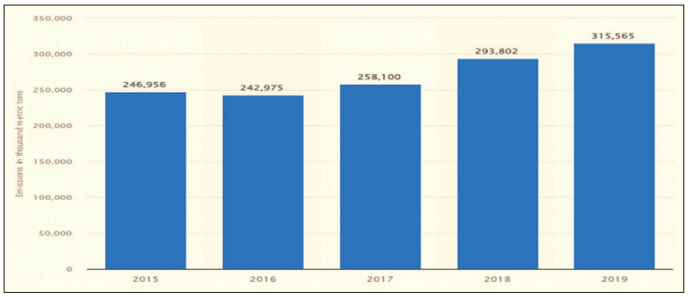


Figure 2: Carbon emission in Indonesia

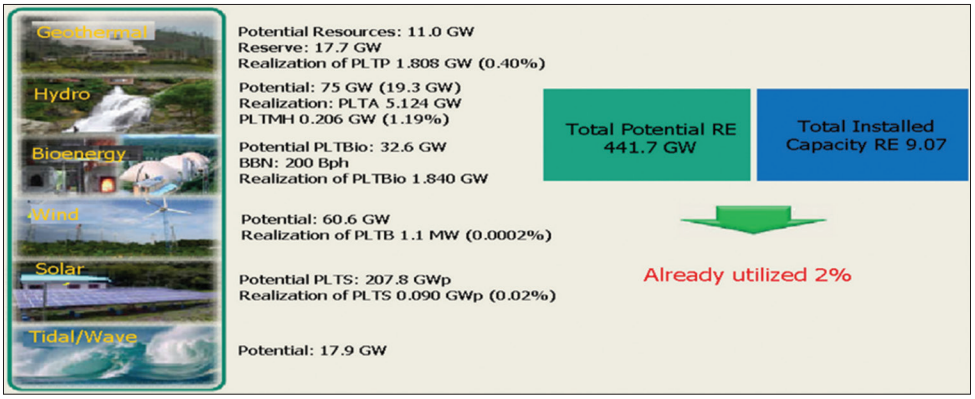


Source: World development indicator-data.worldbank.org

The world recently battled with pandemic situation; however, the Russia-Ukraine crisis arise which is the continuation of 2014 crisis. The crisis has a greater impact on world economic growth and energy industry. The reason is both the countries play essential role in these areas. Russia contains world's largest natural gas reserves. Besides the country is also known to have a 2nd largest coal reserves and 3rd largest energy consumer (Chien et al., 2023c). This recent crisis indicates that Russia got the potential punitive sanction. It means the country can cause disruption in global supply chain and increase prices. The conflict also spills a negative effect economic growth, hence, affect economic recovery of emerging economies such as Indonesia. With the continuation of this conflict, various countries might decline commodity entries such as oil which might fluctuate energy prices. It also affect government spending especially in energy subsidizing which would depress the budget (Chien et al., 2023b; Jargin, 2022). The whole debate motivates us to explore the association energy price fluctuations, environmental governance, and energy transition on carbon emissions in the context of Indonesia.

There is a lot of literature on the environment as well as social sustainability. Few gaps that exist in the literature and the present investigation is addressing are (1) although the carbon emission along with energy prices fluctuations, environmental governance, RE output, RE consumption, energy imports and population growth has been researched although from different perspectives in different times in different economies but still not reached its peak as there are numerous of aspects pertaining to carbon emission are need to be explored particularly in the top polluted economies, (2) _ENREF_7 Li et al. (2020a) and Ike et al. (2020) investigated whether the energy prices effect the carob emission, however, the study extends the framework by adding environmental governance, RE output, RE consumption, energy imports in Indonesian context with fresh data set. (3) Chien (2023) and Liu et al. (2020) investigated whether there is any sort of association between environmental governance and carbon emission, however, the study also adds energy prices fluctuations in the extended framework by focusing on Russian-Ukraine post conflict, (5) Chen et al. (2019) and Magazzino et al. (2021), checked whether the RE output affect the carbon emission in the recent times, whereas the present study will also check it with the addition of variables like energy prices fluctuations, environmental governance, RE consumption, energy imports and population growth with

Figure 3: RE potential in Indonesia



fresh data set, (6) Dong et al. (2020) and Hussain et al. (2023), conducted the investigation to check the relationship between RE consumption and carbon emission, whereas the present study will add the variables energy prices fluctuations, environmental governance, RE output, energy imports and population growth. The present investigation pertaining a noticeable significance like (1) since the focus on the environmental sustainability is vital with the view to safeguard the future generation from its horrible consequences, the present investigation highlight the need to explore it, particularly in the context of carbon emission, energy prices fluctuations, environmental governance, and population growth perspective, (2) the Russian-Ukraine conflict has forced the world to pay attention towards it with the view to its resolution as it will lead to horrible consequences in future, thus, this investigation is highlighting its resolution importance, (3) will also add the literature on the topic of carbon emission, (4) provide a guideline as well as help to the ecological professionals to review and upgrading their policies with the aim of mitigating the carbon emission to achieve the environmental particularly in Indonesia (5) although there are numerous aspects of carbon emission has been explored till now, despite that there still numerous remained hidden, therefore, the investigation helps to scholars to explore new avenues.

2. LITERATURE REVIEW

Literature proposed that energy prices affect carbon emissions. For suppose, Li et al. (2020a), explored whether energy prices play any sort of role in mitigating CO_2 emissions in Indonesia. Sample was analyzed through STIRPAT estimator, and it was revealed that energy prices have a considerable negative influence on Indonesia's CO_2 emissions. This also identifies the large direct impact of the price shift in the focus province on CO_2 emissions as well as the indirect impact of changes in energy prices in neighboring provinces. After taking into account the impact of CO_2 emissions from earlier periods, there is still a negative impact of energy prices on CO_2 emissions that is qualitatively unchanged. Similarly, Zhang et al. (2023a and b), investigated whether environmental quality i.e. carbon emission is get affected by income, energy prices as well as trade. Further, RE plays any sort of role in the betterment of environment quality by mitigating CO_2 emission. The sample from G-7 economies was analyzed via DOLS method and outcomes outlined that trade volume increases CO_2 emissions whereas RE and energy costs reduce it. Further, that energy prices have a detrimental impact on CO_2 emissions. Although the environmental Kuznets curve theory is supported at the panel and national levels, the effects of RE trade and consumption vary between nations. Additionally, Zhang et al. (2021), investigated whether carbon emission is get affected by energy prices, taxation as well as population. The investigation was carried out on the 21 European economies. The investigation used a sample of 10 years. The sample tenure ranged between 2007 and 2017. Investigation via VECM estimator revealed that while urbanization decreased residential carbon and greenhouse gas emissions, population growth increased them. The sample was further separated based on economic development, and the results demonstrate the geographical variety of demographic characteristics and the effects of energy prices on carbon and greenhouse gas emissions. Finally, the time-varying coefficient test shows that during the study period, urbanization's detrimental effects have diminished over time while industrial production's beneficial effects on greenhouse gas emissions have increased.

One of the prime sources to achieve environmental sustainability by controlling carbon emissions is governance. The laws and legislations with the help of proper governance can lead to its control as well as mitigate the carbon emission. There is a significant nexus between carbon emission and governance. Danish et al. (2019), identified whether governance particularly the environment plays any sort of role in mitigating carbon emissions in BRICS sample. With the help of the WP integration technique, it is revealed that governance decreases CO_2 emissions and has adverse, statistically significant effects on CO_2 emissions, contributing to the environmental Kuznets curve theory. Similarly, Chen et al. (2023), explored the association between carbon emission and economic growth. Moreover, this relationship is get affected by governance. The investigation was carried out on the 5 high-carbon emission economies. It is revealed that different governance mechanisms have an impact on emission levels in nations with high CO_2 emissions. Overall, environmental quality is improved through political, economic, and institutional governance. Further, good governance must employ efficient techniques to improve and safeguard environmental quality. Similarly, Shahid et al. (2023), investigated whether there is any sort of association between the triangle of governance, CO_2 emissions, and human development in 44 economies of the Sub Sahara. Investigation revealed that the net impact of CO_2 emissions on inclusive development is negative. The modulation of CO_2 emissions by institutional governance has a detrimental overall impact on inclusive human development. Fortunately, the related interacting effects are favorable, which shows that improving good governance is necessary to provide favorable net impacts. There comes a point in institutional governance policy when the detrimental impact of CO_2 emissions on inclusive human development is totally mitigated.

Energy production from traditional resources is one of the prime causes of carbon emissions, thus, the world is switching to RE. RE production or output leads to mitigating carbon emissions. Chen et al. (2019) explored the association between CO_2 emission, economic growth, renewable as well as non-RE production, and trade in China. The long-term projections demonstrate that rising non-RE use and GDP increase CO_2 emissions but rising RE use and overseas trade reduce CO_2 emissions. The short-term Granger causality tests reveal that there are causal relationships that flow in both directions, from non-RE sources like CO_2 emissions and international commerce to sources of RE. Similarly, Vu et al. (2023b), investigated the nexus between CO_2emission, renewable as well as non-RE production, economic growth, and international trade. The investigation was carried out in Italy. The investigation used a sample of 51 years. The sample tenure ranged between 1960 and 2011. The gathered sample was analyzed with the help of the ARDL approach. The results of the investigation revealed that the generation of renewable power per capita lowers the level of CO_2 emissions per capita in both the short- and long-term, but international commerce only has a favorable long-term impact

on carbon dioxide emissions per capita. According to the results, generating power from renewable sources is a crucial strategy for eventually lowering pollution emissions. Moreover, Sinha and Shahbaz (2018), investigated whether RE generation plays any sort of role in mitigating carbon emissions in India. Investigation revealed while the long-run elasticity of energy consumption is shown to be larger than the short-run elasticity, RE has been demonstrated to have a considerable negative influence on CO_2 emissions. Additionally, commerce and carbon emissions are inversely related.

The excessive usage of energy increases the pressure on energy production. The energy production resources decide the carbon emission. The production of energy from renewable resources results in mitigating carbon emissions. RE consumption has a significant effect on carbon emissions. In this context, Dong et al. (2020), investigated how the consumption of RE results in mitigating carbon emissions in selected 120 economies. Investigation revealed that the use of RE has a small but negative impact on CO_2 emissions. Additionally, Zafar et al. (2019), investigated whether the stock market, development of the banking sector along with RE consumption affect carbon emission. The investigation was carried out on the G7 as well as N-11 economies. Investigation revealed that RE improves environmental quality by lowering the intensity of carbon emissions for both sets of panel nations. In G-7 nations, the banking development index reduces carbon emissions, but in N-11 nations, carbon emissions rise. Similar to this, the stock market development index drives up carbon emissions in G-7 nations while driving down emissions in N-11 nations. Overall, increased carbon emissions caused by economic expansion and fixed capital formation reduce environmental quality. Based on the empirical findings for both sets of nations, this paper makes policy recommendations. Moreover, Khattak et al. (2023), investigated the association between non-renewable and RE consumption and carbon emission in 74 economies of the world. Through HPC technique, investigation revealed that the use of non-RE has a favorable influence on environmental deterioration, whereas the use of RE has a negative impact on environmental deterioration and aids in reducing environmental dangers. Like how economic growth has an adverse and severe effect on environmental deterioration.

Developing countries all around the globe result in importing energy due to numerous resources like cots factor, and lack of natural resources. In this case, they import energy to fulfill their needs. This process also affects carbon emissions. In this context, Naimoğlu (2022), investigated whether nuclear energy along with energy imports and energy prices, affect carbon emissions. The investigation was carried out on the 10 energy import economies. The investigation used a sample of 30 years. Investigation revealed that both nuclear energy consumption and energy costs lower CO_2 emissions. However, imports of energy result in higher CO_2 emissions. Additionally, Lin and Raza (2020), investigated energy security indicators (inclusive of energy imports) and their association with carbon emission in developing economies. With the help of the MARKAL framework, investigation revealed that while total RE will grow by 28%, the supply of primary energy will only slightly decline. The transportation industry and other sectors would consume the most fuel, resulting in a rise in CO_2 emissions of 407.49 Mt in 2040, which might be mitigated by the use of RE sources. Finally, in the reduction scenarios that will reduce cost, CO_2, and energy supply, energy supply and security are at their best. Moreover, Lan et al. (2022), investigated whether there is any sort of co-benefits in case of reduction in carbon emission in Thailand. With the help of the MARKAL framework, investigation exposed that the electricity industry would reduce CO_2 emissions by the most (nearly 60%), followed by the industrial and transportation sectors. The reduction in SO_2 emissions from the base case level under the 30% CO_2 emission reduction objective would be 43%. The total net energy imports into the nation from 2005 to 2050 would be decreased by between 16,000 and 26,000 PJ from the base case emission level if CO_2 emissions were to be lowered by 10-30%. The major energy supply system would be diversified under the CO_2 emission reduction objectives, using less coal and more natural gas, biomass, and nuclear fuels.

Literature proposed that 25% of global energy consumption and 23% of carbon emissions are attributed to the transportation industry. Investigating the combined impact of fossil fuel energy consumption, economic growth, and total population on CO_2 emission based on environmental deterioration in the transportation sector is therefore important. Mohsin et al. (2019), exposed whether energy consumption, economic growth along with population growth results in effect CO_2 emission. The investigation was carried out in the transportation sector of the world. They applied the ARDL and other related approaches for analysis. Results revealed that urbanization-based environmental deterioration increased with EG, urbanization, and energy use. Intriguingly, energy consumption has grown by 13.5% throughout this time period, demonstrating the strong dependency of economic growth on energy use. Additionally, there is a positive correlation between CO_2 emissions and per-person energy usage. Similarly, Sadiq et al. (2023), explored CO_2 emission, population growth, production, economic development, and energy consumption. Results revealed that in the short run, the factors including PG, EG, rural population expansion, and livestock output increases CO_2 emissions. EG, rural population expansion, livestock production, and EU all exhibit positive interactions with CO_2 emissions over the long and short terms, but food production and urban population growth have negative interactions with CO_2 emissions over both the long and short terms. Additionally, Khan et al. (2021a) investigated whether natural resources, energy consumption along with population growth affect CO_2 emission in terms of the environment in the USA. Investigation revealed that environmental quality is enhanced by using natural resources and RE, Further, population increase and non-RE both affect environmental quality, there is a bidirectional comparison of natural resources, CO_2 emissions, and ecological impact and there is also a clear correlation between population expansion, ecological footprint, and CO_2 emissions.

3. METHODOLOGY

3.1. Econometric Model

The methodological outline followed is presented in Figure 4. The research analyzes the impact of energy price fluctuation,

environmental governance, energy transition, energy import, and population growth on carbon emissions in Indonesia (Figure 5). The researchers get the secondary data from 1986 to 2019 from International Energy Agency (IEA) and WDI databases. The article developed the estimated equation given below:

$$CO2E_{it} = \alpha_0 + \beta_1 EPF_{it} + \beta_2 EG_{it} + \beta_3 REO_{it} + \beta_4 REC_{it} + \beta_5 EI_{it} + \beta_6 FA_{it} + \beta_6 PG_{it} + e_{it} \quad (1)$$

CO_2 emissions which is the dependent variable of the study is measured through carbon emissions matric per capita. In addition, energy prices fluctuation measured with the percentage change in energy prices,

Figure 4: Research sequence

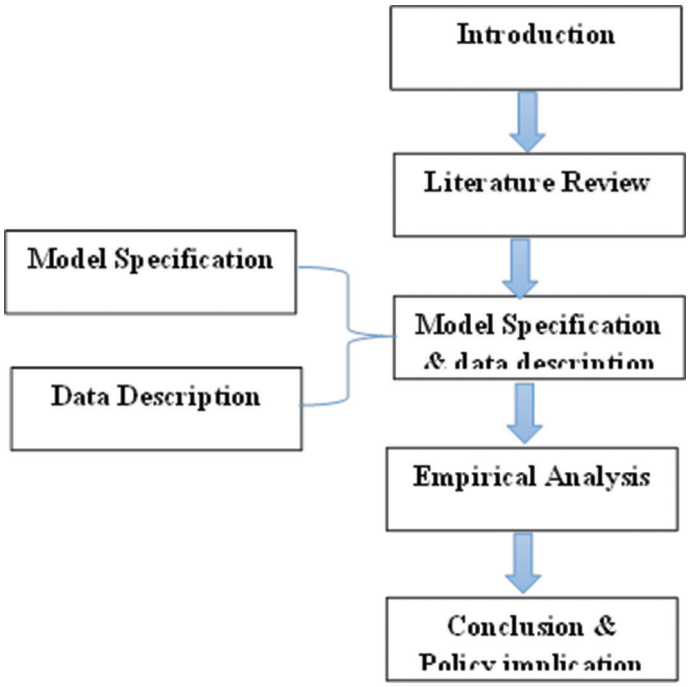
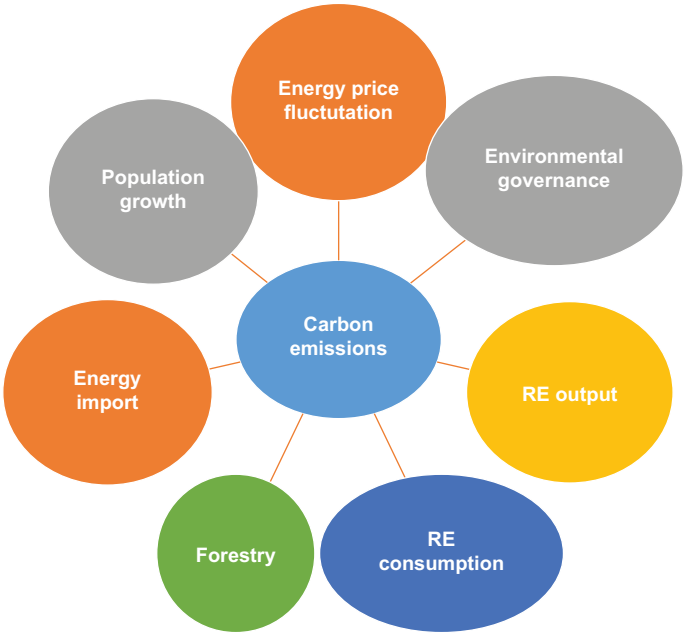


Figure 5: Research framework



environmental government measured with environmental taxes to total taxes, and energy transition measured with REO (% of total energy output) and REC (% of total energy output). Finally, the research also used two control variables, such as energy import measured with energy import (% of energy use) and population growth measured with population growth (annual percentage).

The study applied various techniques in order to assess data properties, unit root and relationship among variables. These techniques include descriptive test, correlation method and Phillips–Perron (PP) and Augmented Dickey-Fuller (ADF) tests. Moreover, by applying the Westerlund and Edgerton (2008) approach, co-integration was also checked. The equations in this context are stated below:

$$LM_{\varphi}(i) = T\hat{\varphi}_i(\hat{r}_i / \hat{\sigma}_i) \quad (2)$$

$$LM_{\tau}(i) = \hat{\varphi}_i / SE(\hat{\varphi}_i) \quad (3)$$

The research also investigated the connection among the understudy constructs via ARDL model as the model is appropriate when the constructs have no unit root at I(0) and I(1) (Lin et al., 2022). It also fixates the heteroscedasticity and autocorrelation issue (Nazir et al., 2018). The equation is given below:

$$\begin{aligned}\Delta CO2_t = {} & \alpha_0 + \sum \delta_1 \Delta CO2_{t-1} + \sum \delta_2 \Delta EPF_{t-1} \\ & + \sum \delta_3 \Delta EG_{t-1} + \sum \delta_4 \Delta REO_{t-1} + \sum \delta_5 \Delta REC_{t-1} \\ & + \sum \delta_6 \Delta EI_{t-1} + \sum \delta_7 \Delta FA_{t-1} + \sum \delta_8 \Delta PG_{t-1} \\ & + \varphi_1 CO2_{t-1} + \varphi_2 EPF_{t-1} + \varphi_3 EG_{t-1} + \\ & \varphi_4 REO_{t-1} + \varphi_5 REC_{t-1} + \varphi_6 EI_{t-1} \\ & + \varphi_7 FA_{t-1} + \varphi_8 PG_{t-1} + \varepsilon_t \end{aligned} \quad (5)$$

Finally DARDL approach introduced by Jordan and Philips (2018) has been employed to cover all the problems not covered by the ordinary ARDL model.

$$\begin{aligned}\Delta CO2_t = {} & \alpha_0 + \sum \delta_1 \Delta CO2_{t-1} + \sum \delta_2 \Delta EPF + \sum \delta_3 \Delta EPF_{t-1} \\ & + \sum \delta_4 \Delta EG_t + \sum \delta_5 \Delta EG_{t-1} + \sum \delta_6 \Delta REO_t \\ & + \sum \delta_7 \Delta REO_{t-1} + \sum \delta_8 \Delta REC_t + \sum \delta_9 \Delta REC_{t-1} \\ & + \sum \delta_{10} \Delta EI_t + \sum \delta_{11} \Delta EI_{t-1} + \sum \delta_{11} \Delta FA_t \\ & + \sum \delta_{12} \Delta FA_{t-1} + \sum \delta_{13} \Delta PG_t + \sum \delta_{14} \Delta PG_{t-1} + \varepsilon_t \end{aligned} \quad (6)$$

4. EMPIRICAL FINDINGS

The article investigates constructs details via descriptive statistics. The outcomes exposed that the CO_2 average value was 4.315 tons per capita followed by EPF 5.257, EG 0.091, REO 19.488 percent, REC 22.811, EI 5.803 and PG 0.842. These values are given in Table 1.

As discussed, correlation was performed as it is exposed in Table 2 that energy price fluctuation, environmental governance, RE output, RE consumption, energy import, and population growth have a positive linkage with CO_2 emissions in Indonesia.

Furthermore, the research also investigates the unit root among constructs to apply the appropriate model by applying PP and ADF tests. The outcomes exposed that the CO_2, EPF, EG, EI, and PG have no unit root at I(0), while REO and REC have no unit root at I(1). These values are given in Table 3.

The outcomes in Table 4 exposed that the t-values are bigger than 1.96 and the P<0.05. These outcomes indicated that the co-integration exits. These values are given in Table 4.

The article also checks the nexus among the variables by applying the DARDL approach. The outcomes exposed that energy price fluctuation, environmental governance, RE output, RE consumption, energy import, and population growth have a positive linkage with CO_2 emissions. These values are given in Table 5.

5. DISCUSSION

The results showed that energy price fluctuation negatively affects CO_2 emissions. Hence, show consistency with prior evidence (Chevallier et al., 2019; Li et al., 2020b; Mensah et al., 2019). This shows that when energy prices fluctuate, people tend to utilize energy economically and try to reserve energy resources for future supply. As a result, there is absolute use of a small amount of energy for the same outcomes. The decrease in the total amount of energy reduces CO_2 emission, which is common during manufacturing and transportation. Moreover, when energy prices go high, the total use of energy resources decreases within the economy. When the total amount of energy decreases within the economy, the economic practices release less amount of energy. Also, when there is uncertainty in energy prices, individuals and firms both tend to utilize RE, which costs less relatively. Hence, energy price fluctuation reduces CO_2 emissions. The negative relation of governance with carbon emissions also confirms the prior studies evidence. Such as study of Zhang et al. (2021), indicates that when the firms' management applies environmental governance, it regulates the business practices as they may not have any impact on the environment where these activities are being performed. The eco-friendly regulations overcome the use of energy resources and reduce CO_2 emissions. Similarly, Vu et al. (2023a) also highlights that when the rules and regulations developed and approved by the board of directors in the environmental regulatory body are enforced on the businesses, the managerial bodies make them followed by the business personnel. In this situation, toxins like CO_2 emissions are minimal. According to Zhou et al. (2019), if the environmental governing bodies consider their responsibilities towards the environment and public well-being and implement the environmental rules and regulations, they help overcome CO_2 emissions. Also, the negative relation of RE with carbon emissions also confirms that mostly the smoke and wastes from the large machines and technical processes create CO_2 gas in heavy amounts because, during these processes, energy resources containing carbon are utilized. If RE production increases, there is an energy transition from fossil fuels to clean energy. This reduces smoke and waste, and thus, it mitigates CO_2 emissions (Lin and Zhu, 2019). The results are also consistent with Abbasi et al. (2021) and Jamil et al. (2022) which stated that If a country succeeds in producing RE in huge amounts, large energy resources that have a neutral impact on the environment are available in the market. When RE resources are utilized in place of fossil fuels, CO_2 emissions decrease. Moreover, the increasing RE output enables business firms to access clean energy sources and mitigate the CO_2 emissions from business practices that require heat, light, cooling, or motion.

The negative association of RE consumption and energy import with carbon emissions is also the reflection of prior evidences as prior studies argued that where there is increasing use of RE in households and business procedures, CO_2 is reduced and increasing RE consumption does not create waste and smoke, so it is less likely to create CO_2 emissions (Haldar and Sethi, 2021; Sahoo and Sahoo, 2022). Also, the countries which open the ways for firms or individuals to attain energy resources from foreign countries, the clean energy import discourages the use of coal, oil, natural gas, ore, or nuclear power and therefore, the CO_2 emissions are minimal (Moslehpour et al., 2023). Baloch et al. (2019) and Tran (2022) also in line with present findings revealed that the attainment of sustainable energy technologies

Table 1: Descriptive statistics

Variable	Obs	Mean	SD	Min	Max
CO2	37	4.315	2.276	1.476	7.968
EPF	37	5.257	6.401	−1.401	24.257
EG	37	0.091	0.083	0.000	0.271
REO	37	19.488	3.111	15.037	26.372
REC	37	22.811	9.344	11.34	36.305
EI	37	5.803	8.765	−6.556	22.433
FA	37	4.563	9.423	1.762	22.31
PG	37	0.842	0.387	0.238	1.610

Table 2: Correlation

Variables	CO_2	EPF	EG	REO	REC	EI	FA	PG
CO_2	1.000							
EPF	−0.449	1.000						
EG	−0.466	0.584	1.000					
REO	−0.436	0.054	0.457	1.000				
REC	−0.965	0.487	0.621	−0.217	1.000			
EI	−0.980	−0.477	−0.438	0.495	−0.924	1.000		
FA	−0.512	0.023	0.241	0.121	−0.012	−0.212	1.000	
PG	−0.825	0.617	0.838	−0.038	0.881	−0.828	0.431	1.000

Table 3: Unit root test

ADF	PP			
Series	Level	First difference	Level	First difference
CO_2	−4.902***	------	−2.784***	------
EPF	−3.144***	------	−3.773***	------
EG	−2.238***	-----	−4.291***	------
REO	------	-5.291***	------	−4.664***
REC	------	−3.211***	------	−5.321***
EI	−4.391***	------	−5.483***	------
FA	------	−5.312	------	−2.315
PG	−3.783***	------	−4.673***	------

Table 4: Co-integration test

Model	No shift		Mean shift		Regime shift	
	t-value	P-value	t-value	P-value	t-value	P-value
LM_τ	−4.654	0.00	−5.774	0.00	−5.545	0.000
LM_φ	−4.443	0.00	−5.383	0.00	−5.673	0.000

Table 5: Dynamic ARDL model

Variable	Coefficient	t-Statistic	Prob.
ECT	−3.654***	−5.562	0.000
EPF_{t-1}	−3.856***	−4.391	0.000
EPF	−4.372***	−5.390	0.000
EG_{t-1}	−4.291*	−1.979	0.044
EG	−3.288***	−4.311	0.000
REO_{t-1}	−3.289***	−5.019	0.000
REO	−4.377***	−5.409	0.000
REC_{t-1}	−3.298**	−2.783	0.032
REC	−4.918**	−2.111	0.037
EI_{t-1}	−0.382***	−4.991	0.000
EI	−1.028***	−5.101	0.000
FA_{t-1}	−0.412***	−3.191	0.000
FA	−2.028***	−4.101	0.000
PG_{t-1}	−1.266***	−3.728	0.003
PG	−0.487**	−4.222	0.000
Cons	−0.476**	−4.762	0.000

R square=60.372, Stimulation=5000

from abroad enables the country to reduce CO_2 emissions and their impacts on the environment. The results also showed that population growth shares negative relation with CO_2 emissions. Hence, consistent with the study of Moslehpour et al. (2021), which denotes that in areas with a huge population, the education system is effective and creates environmental awareness in people. People with better environmental knowledge design their business practices to overcome CO_2 emissions. Khan et al. (2021b), also implied that the increasing population growth promotes business and technological development. Technical innovation in businesses is helpful in mitigating CO_2 emissions. Weber and Sciubba (2019) also produced similar evidence and argued that the region with high population growth has fast development and efficient human capital. In this region, eco-friendly innovation fast develops, and CO_2 emissions are reduced.

6. CONCLUSION AND IMPLICATIONS

The objective of the study is to investigate the role of energy price fluctuation, environmental governance, energy transition, energy import, and population growth in mitigating CO_2 emissions. The results showed that when there is consistent fluctuation in energy prices, people tend to reduce energy use or utilize RE, which costs less relatively. So, there is a reduction in CO_2 emissions. The findings denoted that if environmental regulators effectively implement environmental governance in the economy, there will be fewer CO_2 emissions. The results indicated that the increasing RE output increases the supply of alternative energy sources that leave no toxins or wastes. So, CO_2 emissions decrease. The results also conveyed that the increasing RE consumption does not create waste and smoke, so it is less likely to create CO_2 emissions. Moreover, the study concluded that the import of clean, affordable, and RE or resources used to produce such energy people inland to overcome CO_2 emissions. The results showed that the region with high population growth had informed human resources, advanced technologies, and innovative infrastructure that CO_2 emissions are reduced.

The study guides that energy prices should be managed to encourage RE as it would decrease CO_2 emissions. The study also conveys that environmental regulators must enforce environmental governance effectively in order to restrict emissions. Moreover, policies must be formed to apply innovative processes to have a larger amount of RE output and, therefore, decrease CO_2 emissions. There is a suggestion that there must be an energy transition through increased renewable consumption, and thereby, CO_2 emissions can be reduced. The study implies that the government must support energy imports to mitigate CO_2. Moreover, the study guides that if the population is getting higher, there must be progressive activities in the respective areas. It is sure to overcome CO_2 emissions.

7. LIMITATIONS AND RECOMMENDATIONS

There are some limitations still linked to the present study, and authors are recommended to show more attention. The authors have checked the role of only energy price fluctuation, environmental governance, energy transition, energy import, and population growth in mitigating CO_2 emission. They utterly ignored some significant factors like green finance, eco-innovation, green supply chain, etc. The researchers must feel the necessity to increase the number of factors effective to mitigate CO_2 emissions. In addition, for the empirical research, data were acquired from Indonesia only after the post-Russia-Ukraine Conflict. For the general findings related to the relationship between constructs, data must be attained from diverse economies and for a longer period.

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