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# The Impact of Renewable Energy Consumption, International Investment, Urbanization, Economic Growth on Carbon Dioxide Emission

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## Abstract

The recent debate across the European Union is to reduce carbon dioxide emissions by 2030 while maintaining rapid economic growth. Achieving this dynamic equilibrium is complicated for countries. Energy demand is rising across European Union countries. Equivocally, conventional energy still exists primarily as an energy source. As a result, finding alternative strategies to minimize carbon dioxide emissions and boost the share of clean energy in overall energy consumption is crucial for governments. Therefore, this study analyzed the impact of Renewable energy, foreign direct investment and urbanization economic growth on carbon dioxide emission in some selected European countries spanning from 1990-to 2018. The study used ADF-fisher, PP- fisher unit root, Johnson fisher, Pedroni Kao cointegration, and Pair wise Granger causality approach. Findings of this indicate that foreign direct investment increased CO2 emissions, Urbanization reduces the quality of the environment and lastly Renewable energy minimizes environmental pollution. The study concluded by making suggestions regarding pertinent policy implications for reducing environmental pollution in European Union countries.

## Introduction

The year 2020 experienced a decline in global carbon dioxide emissions after decades of it rising. However, evidence of rapid rebound in energy demand and emissions in many economies suggests that $CO_2$ emissions will rise significantly in the years ahead [1], as environmental damage is becoming threatened as a result of the rising temperatures [2].Therefore, preserving the environment has emerged as one of the most pressing global issues in recent times. The Kyoto Protocol signed in 1997 intends to minimize greenhouse gas emissions which seem to contribute to environmental deterioration substantially and are responsible for global warming. The Kyoto protocol agreement covers six categories of Greenhouse Gas (GHG) emissions: Carbon Dioxide (CO2), Methane (CH4), Nitrous Oxide (N2O), Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs) and Sulphur hexafluoride (SF6).Co2 emissions being the most common greenhouse gas is the most significant greenhouse gas in terms of quantity [3]. Most greenhouse gas emissions are caused by fossil fuel consumption [4,5]. Environmental policymakers and energy economists advocate for the use of clean energy sources rather than conventional energy sources. It has been observed that clean energy sources help to mitigate $CO_2$ emissions [6-8]. As long as renewable energies are used responsibly and do not pollute the environment by decreasing carbon dioxide and other greenhouse gases, their usage is not restricted. Rising energy demand for growth and advancement of clean energy sources

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is required for countries to achieve sustainable development. This is an effective way to accomplish this goal in E.U. countries. Although the European nation signed the Kyoto Protocol to handle carbon dioxide emissions, there are significant environmental concerns in the region, especially considering the area's current economic expansion.

Another significant aspect that contributes to environmental degradation is foreign direct investment. As financial development promotes economic growth, this economic expansion encourages more international research and development investments, leading to increased energy usage and thus increased $CO_2$ emissions. Foreign direct investment stimulates a country's manufacturing production process, develops its logistics, and industrializes it; nonetheless, it increases its energy utilization and environmental pollution [9-11].

On the other hand, the world is becoming increasingly urbanized. Urbanization worldwide has reached unprecedented proportions in the last 200years and this trend is expected to continue [12]. According to the united nation, the world's urban population will nearly double from three billion in 2007 to six billion in 2050, increasing almost fifty percent [13]. This urbanization experience has exacerbated the quality of the environment unequivocally. Although urbanization poses significant challenges, efforts to stifle it via exclusionary policies are likely to be socially, economically, and environmentally detrimental [15-17]. Meanwhile, urban environmental quality, including water and air pollution, is worsened. Research that could close the knowledge gap on urban carbon dioxide emissions exposures is needed to address the challenge and maximize its benefits.

Nonetheless, the impact of economic growth on environmental quality has emerged as a crucial question, with growing concern about preserving the environment. In the European Union, a crisis about carbon dioxide emission and finding accurate ways to minimize it began years ago [18-25]. Numerous extant studies have dealt with the link between $CO_2$ emission and economic growth.

This study aims to identify the essential elements that contribute to the deterioration of environmental quality in European Union (E.U.) countries as assessed by $CO_2$ emissions. The E.U. is a group of European countries whose primary goal is to break down trade, economic and social barriers to enhance prosperity in these areas. The E.U. has introduced a series of economic reforms to speed up economic development to achieve such a purpose. These policies may have improved the economic growth, but they may adversely affect the environment. The dilemma of environmental pollution in E.U. countries previously worsened due to increased economic industrialization, increased conventional energy usage, and the growth of many large cities. Also, it is critical to conduct a study in European Union countries, given the massive urgency of climate change.

Nonetheless, pollution levels vary significantly across the continent. Figure one (1) below presents the death rate attributed to environmental pollution in highly polluted E.U. countries. From figure one, with a death rate of 91 per 100,000 people, Latvia has the highest rate of ecological pollution-related deaths, whereas Sweden has a death rate of 0.4 per 100,000 people. Meanwhile, according to projections from member states, emissions will continue to decline, and the E.U. intends to exceed its 2020 objective. Without any additional steps, environmental pollution is expected to be thirty percent lower in 2030 than in 1990 under current regulation from **Figure 2**.

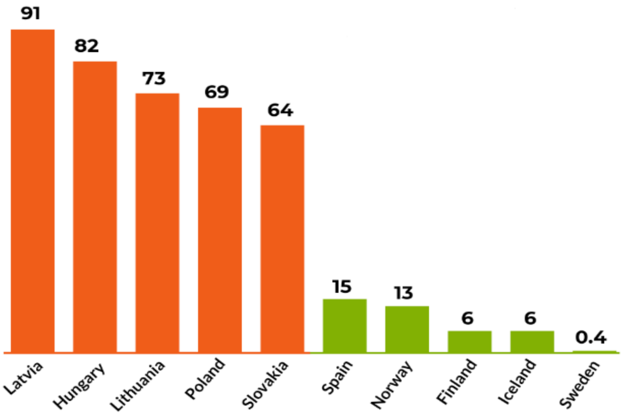

**Figure 1:** Death rate attributed to environmental pollution in highly polluted E.U. countries.
**Source:** Greenmatch, 2021 [26].

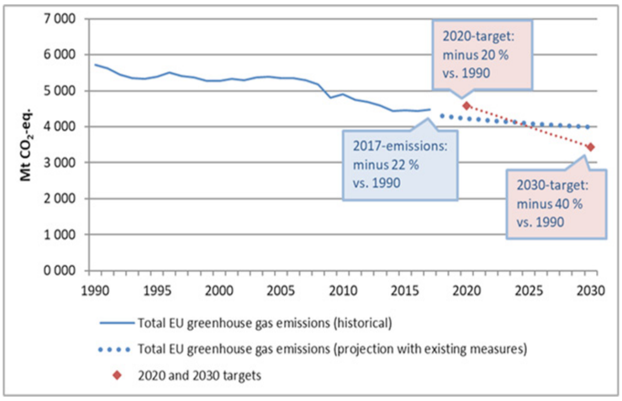

**Figure 2:** EU Greenhouse gas emissions (Historial-1990 to 2017), GHG emission forecast 2018 to 2030.
**Source:** Amanatidis, (2019) [27].

This study differs from prior European Union (E.U.) studies in the following ways. For example, this is the single study that employs both panel Johnson fisher panel co integration and panel Pair wise Granger causality based on the vector error-correction, Vector Autoregressive Model (VAR**)** model simultaneously. Relative to Asiedu et al.,'s (2021) study, which is the closest to our study, we considered a more appropriate determinant of environmental pollution. We introduced urbanization as an additional variable. Our study captured the evolution and structure of population in E.U. countries by introducing urbanization. In addition, many of the studies employed total clean energy consumption and clean energy production against $CO_2$ emissions. This study differs from those studies by utilizing renewable energy consumption as the share of renewable energy in total final energy consumption effect on $CO_2$ emissions to approve or disapprove the missed results existing.

To reflect on the background introduction with the result, we examine the relationship between renewable energy, foreign direct investment, economic growth, urbanization, and $CO_2$ emissions in E.U countries from 1990-2018. The study is organized into four sections. Section one contains the introduction. Part two tackles the literature review. Section three dealt with the methodology. Section four tackles empirical analysis and results. Part five has the conclusion and policy implication section.

## Review of literature critically

### Renewable Energy (REN) and Carbon dioxide emissions ($CO_2$ emissions)

Asiedu, et.,(2021) study is dedicated to understanding the various interrelationship between clean and non-renewable energy use, $CO_2$ emission, and growth in twenty-six European nations. The information was gathered from WDI and covered the period from 1990 to 2018. The granger causality test revealed a long-term connection between clean, non-renewable energy, $co_2$, and economic expansion. The findings from this study contradict the findings of others, although they suggest a unidirectional causation relation between renewable energy and $CO_2$. The result indicates that clean energy and non-renewable energy sources are interdependent and interchangeable. At the same time, [28] study aims to examine the STIROAT model's applicability in assessing carbon dioxide emissions from OECD nations from 1980 to 2011. According to the empirical findings, renewable energy usage correlates with decreased $co_2$ emissions. At the same time, [29] study outcome indicated that renewable energy contributes significantly to $CO_2$ emissions in the SSEA regions. Furthermore, the empirical results indicated that middle-income nations are experiencing a substantial increase in clean energy/fossil fuel energy consumption, resulting in greenhouse emissions in the SSEA regions. Also, [30] also examined the interplay between renewable energy uses, economic growth, and $co_2$ emissions. The author's utilized the structural VAR method. A unit root test of the variables in question shows that they are non-stationary at their level and stationary in the first difference form. The study found that as clean energy use is encouraged, GDP rises, and $co_2$ emissions fall. The variance decomposition highlights the importance of using clean energy sources in reducing the forecast error variance of economic growth and carbon dioxide emissions. Correspondingly, [31] study utilized the ARDL bound testing approach in exploring the interaction between $CO_2$ emission, population growth, foreign investment, and renewable energy in Pakistan. The causal link was checked with the pair wise Granger causality method. Findings expressed that $CO_2$ emission adversely affect clean energy. Adding more, [32] examined the impact of renewable energy. Non-renewable energy consumption and real income on $CO_2$ emissions evidence from structural breaks test. The studied variable became stationary at the first difference, according to the Zivot-Andrews unit rot test with structural breaks. $CO_2$ and renewable energy are co integrated according to the Gregory-Hansen co integration test with structural breaks. Meaning, improvement in renewable energy usage alleviates environmental according to the long-run projection from the ARDL model.

### Foreign Direct Investment and Carbon dioxide $CO_2$ emission

[33] analyzed how economic policy uncertainty and FDI impacted $CO_2$ emissions in 24 industrialized and developing nations from 2001 to 2019. Granger causality approach validated the causal relationship between variables. Conversely, a one percent rise in international investment is related to decreased $CO_2$ emissions. Likewise, [31], utilized the ARDL bound testing approach and Granger causality approach to analyzed the relative interaction of $CO_2$ emission, population growth, foreign investment, and renewable energy in Pakistan. The result exposed that FDI and population growth have a significant positive interaction with $CO_2$ emission, which means that a stringent benchmark is needed from the government of Pakistan to improve the development of the economy via the demonization of carbon dioxide emission. Alike, et al., investigated the role of FDI and globalization on $CO_2$ via the channel of energy usage from 1990 to 2017.According to the dynamic regression, FDI does not predict $CO_2$ in the long run. This means that international investment lessens environmental repercussions. Haug and Ucal examined the role of foreign trade on $CO_2$ emissions in Turkey. The study employed linear and nonlinear ARDL. The study indicated that decrease in export reduces $CO_2$ emissions in the long term. In the long run, increases in imports raise $CO_2$ emissions. Export and import were affected positively by urbanization and financial development. The study found that an increase in real GDP per capital minimizes CO2 for the most current decades. For two of the four domains, changes in the overall emissions of $CO_2$ and the country's export and import numbers are reflected in different ways in the sectorial carbon dioxide emission share. In these cases, export leads to lower carbon dioxide shares while imports lead to higher $co_2$ percentage. Equally, [34] examined the link between FDI, renewable energy, non-renewable energy, GDP, and $CO_2$ in 26 European countries. The study employed unbalanced panel data in its analysis. Granger causality indicated significant long-run causality running from FDI to $CO_2$ emissions. Since FDI-Led growth does not appear to apply to both the E.U. countries and the five new member states, FDI-led growth does not appear to be a viable option. On the other hand, the short-term effect of FDI inflows on $CO_2$ emissions in the first to fourth nations is negligible, but this effect is lost in the long-term.

### Economic growth and Carbon dioxide emissions ($CO_2$ emissions)

[35]paper explored the causes and effects of economic growth on $CO_2$ emission in fifty-four nations using simultaneous equation panel data spanning from the period 1990-2011. For all the panels data, the study found a bidirectional correlation between economic growth and $CO_2$ Europe and Asia are exceptions. They also reveal unidirectional causality between-$CO_2$ emission and economic growth except for the Middle East, North Africa, and sub-Saharan countries. In the same way, [36] study in 26 European countries found that GDP increases environmental pollution. [37] conducted a study concerning Malaysia's GDP and carbon dioxide emissions. The study disclosed that in the short run, no causality exists between carbon dioxide emission and GDP. The study found unidirectional causality among GDPand$CO_2$ emissions in the long run. Again, [3] article investigate the connection between European Union economic growth and $CO_2$ emission in the ten selected European nations for the period 1981 to 1995. The findings reveal a significant difference between the most industrialized and the rest of the world. The findings do not appear to advocate a standard policy to reduce emissions. Rather, they suggest that emissions reduction could be achieved by considering each E.U. member state's unique economic condition and industrial structure. [37] examined the link between economic growth and carbon dioxide emission. According to the estimate based on world panel data, the marginal propensity to emit $CO_2$ decreases when GDP per capita increase. Despite this, global $CO_2$ emission will continue to climb at a rate of one-point eight percent per year for the foreseeable future, a conclusion that is unaffected by average output growth. Instead, emissions will continue to rise because lower-income countries with high MPE's will experience the fastest expansion in output and population. In the same way, [38] examined the causal link between economic growth, carbon dioxide emissions, and energy consumption for 116 nations. The author utilized panel vector auto regression and a system-generalized moment method for the period 1990-2014. The empirical results of the study established that economic growth has no causal impact on carbon emissions. However, economic growth harms carbon emissions at the global and Caribbean Latin American levels.

### Urbanization (UBN) and Carbon dioxide emissions ($CO_2$ emissions)

[39] research investigate the effect of urbanization, clean-non-renewable energy, and economic growth from 1990-2016. The study disclosed that urbanization and economic expansion contributes to $CO_2$ emissions. The indicated is apparent that the economy is rising at the expense of the environment while increasing trade that involves a higher level of pollution. Similarly, paper investigates the relationship between urbanization, energy usage, FDI, and $CO_2$ emission in the southeast and south area and its various countries from 1980 to 2012. The authors categorized the total sample countries into 3-subgroups: low-income, middle and high countries. Pedroni's finding demonstrated that regardless of the country's income per capita, urbanization, energy consumption, and $CO_2$ are co integrated. Likewise, [16], utilizing the ARDL bounds test, found that urbanization is the main driver of GHG emissions in the long term. But in the short run, urbanization did not contribute to an increase in GHG emissions.

With new panel estimation techniques called dynamic unrelated seemingly regression, [40] empirical work adds to the current body of knowledge by estimating the influence of industrialization and urbanization on $CO_2$ in the APEC member nation. For the analysis, data from 1990 to 2014 was used. Along with this, it was discovered that urbanization contributes to a higher level of environmental pollution via $CO_2$ [41] conducted an empirical study on what impact does a new form of urbanization has on $co_2$ emission. The study employed an exploratory spatial data analysis model, a spatial economic model, and a threshold model to examine the special autocorrelation of $CO_2$ emissions, the direct and indirect effects of new-type urbanization on $CO_2$ emission, and the threshold characteristics produced by technological progress respectful from 2005 to 2016 in China. The study found that new-type urbanization has a paradoxical influence on carbon dioxide emissions. New-type urbanization has a threshold effect on $CO_2$due to a distinct level of energy-saving and environmental technology.

[42] did a comparative analysis for OECE countries from 1990 to 2011 and reiterated that at a higher level of urbanization decreases environmental quality. [43] study on urbanization, energy usage, and $co_2$ in China found a long-term bi-directional relation between urbanization and $CO_2$. While China's $CO_2$ emissions are expected to rise, there remains significant improvement. Utilizing a comparative approach, [44] studied the relationship between urbanization, energy usage, GPD, trade, and $CO_2$ in Canada and China. The Granger causality test proved that in Canada and Australia, urbanization increases $CO_2$ emissions in the long run. [17] study attests that there is a bi-directional causal link between urbanization and $CO_2$. Besides this, based on the estimates, the urbanization process in the southern common market countries was strongly tied to fossil fuel usage, with the transportation sector, construction sector, and the household as the primary cause of $CO_2$ emissions.

## Research methodology

### Data description

The study utilized panel data from 1990 to 2018 due to its several merits [45]. FDI represent foreign direct investment proxied by net (BoP, current U.S. dollars) FDI is the net inflows of investment to acquire a lasting management interest (ten percent or more of voting stock) in a corporation operating in an economy other than that of the investors.Net FDI outflows are assets, and net inflows are liabilities.GDP is economic growth proxy by GDP per capita growth (annual %), Urbanization (UBN) is measured by access to electricity, urban (% of urban population), $CO_2$ is carbon dioxide proxied by metric tons per capita. $CO_2$ emissions are those stemming from the burning of fossil fuels and the manufacturing of cement. They include carbon dioxide produced during the consumption of solid, liquid, and gas fuels and gas flaring. REN is a renewable energy consumption measured by % of total final energy consumption. FDI, REN, GDP, UBN, and $CO_2$data were from World Development Indicators (WDI). **Table 8** depicts a more detailed data description. **Figure 3** presents the categorical diagrams of the variables under study.

### Model specification

Since the study's primary aim is to analyze the link between renewable energy consumption, foreign direct investment, urbanization, economic growth, and carbon dioxide emission, four models will be dealt with. The models can be displayed as:

$$REN_{it} = \alpha + \beta_1 FDI_{it} + \beta_2 GDP_{it} + \beta_3 UBN_{it} + \beta_4 CO_{2it} + \varepsilon_{it\,(1)}$$

$$FDI_{it} = \alpha + \beta_1 REN_{it} + \beta_2 GDP_{it} + \beta_3 UBN_{it} + \beta_4 CO2_{it} + \varepsilon_{it(2)}$$

$$GPD_{it} = \alpha + \beta_1 FDI_{it} + \beta_2 REN_{it} + \beta_3 UBN_{it} + \beta_4 CO2_{it} + \varepsilon_{it(3)}$$

$$UBN_{it} = \alpha + \beta_1 FDI_{it} + \beta_2 GDP_{it} + \beta_3 REN_{it} + \beta_4 CO2_{it} + \varepsilon_{it(4)}$$

Where α is the intercept, $\beta_{1,}$ $\beta_2$, $\beta_3$, $\beta_4$ are slope coefficient of the model, *t* is time *I* is the cross-section unit, and ε represent the error term. FDI is foreign direct investment GDP is economic growth, UBN is urbanization, $CO_2$ is carbon dioxide emissions, and REN is renewable energy consumption.

### Unit root

Many panel unit tests have been presented to analyze the unit root for the variables. The panel unit root test is based on ADF, PPF, and IPS tests that allow for individual unit root processes. They permit much homogeneity across all panel units. All tests are based on [46] equation below:

$$\Delta y_{i,t} = a_i + \rho_i y_{i,t-1} + \sum_{\square=1}^{\square i} \square\square \beta i,z \Delta y_{i,t-z} + \varepsilon_{i,t}$$

The equation above is based on IPS. It is defined as $H_0$=O for all *I…N* against the alternative Hypothesis, H*i* and $\rho_i$=O for $=N_1+1$..., N, with $O<N_1\leq N$. IPS is based on a separate unit root test of N cross-section units, of which the alternate hypothesis does not have a unit root test for all individual series. The test is based on the Augmented Dickey-Fuller test, which takes average across groups. The outcome of the unit root test is presented in table one.

### Johansen co integration test

The Hypothesis is stated as $H_0$: No co integration. $H_1$:$H_0$ is not valid. Decision criteria: rejection at the 5% level. Reject the null Hypothesis if the values of the trace and max statistics>5% critical value; otherwise, we fail to reject the null Hypothesis.

### Vector error correction model

The VECM allows for a causal link between more than one variable stemming from an equilibrium association, thus characterizing long-term equilibrium alignment that persists further than the short-run adjustment. If variables are non-stationary and become stationary after the first differencing, the Vector Error correction model for the Granger-causality test can be stated as follows:

$$\Delta Y\ =\beta\ +\sum_{\square=1}^{\square 1}\ \beta\ \Delta Y\ +\sum_{\square=1}^{\square 2}\ \beta_{3j}\Delta W_{t-j}+\sum_{\square=1}^{\square 3}\ \beta_{4j}\Delta V_{t-j}+\sum_{\square=1}^{\square 4}\ \beta_{5j}\Delta X_{t-j}+\sum_{\square=1}^{\square 5}\ \beta_{6j}\Delta Z_{t-k}+\beta_7\varepsilon_{t-1}+\mu_{1t},$$

$$\Delta X\ =\beta\ +\sum_{\square=1}^{\square 6}\ \beta\ \Delta X\ +\sum_{\square=1}^{\square 7}\ \beta_{10j}\Delta W_{t-j}+\sum_{\square=1}^{\square 8}\ \beta_{11j}\Delta V_{t-j}+\sum_{\square=1}^{\square 9}\ \beta_{12j}\Delta Y_{t-j}+\sum_{\square=1}^{\square 10}\ \beta_{13j}\Delta Z_{t-k}+\beta_{14}\varepsilon_{t-1}+\mu_{2t},$$

$$\Delta Z\ =\beta\ +\sum_{\square=1}^{\square 11}\ \beta\ \Delta Z\ +\sum_{\square=1}^{\square 12}\ \beta_{17j}\Delta W_{t-j}+\sum_{\square=1}^{\square 13}\ \beta_{18j}\Delta V_{t-j}+\sum_{\square=1}^{\square 14}\ \beta_{19j}\Delta X_{t-j}+\sum_{\square=1}^{\square 15}\ \beta_{20j}\Delta Y_{t-k}+\beta_{21}\varepsilon_{t-1}+\mu_{3t},$$

$$\Delta V\ =\beta\ +\sum_{\square=1}^{\square 16}\ \beta\ \Delta U\ +\sum_{\square=1}^{\square 17}\ \beta_{3j}\Delta W_{t-j}+\sum_{\square=1}^{\square 18}\ \beta_{24j}\Delta V_{t-j}+\sum_{\square=1}^{\square 19}\ \beta_{25j}\Delta Y_{t-j}+\sum_{\square=1}^{\square 20}\ \beta_{26j}\Delta Z_{t-k}+\beta_{27}\varepsilon_{t-1}+\mu_{4t},$$

$$\Delta W_t=\beta_{28}+\sum_{\square=1}^{\square 21}\ \beta_{29}\Delta W_{t-}++\sum_{\square=1}^{\square 22}\ \beta_{30j}\Delta W_{t-j}+\sum_{\square=1}^{\square 23}\ \beta_{31j}\Delta V_{t-j}+\sum_{\square=1}^{\square 24}\ \beta_{32j}\Delta Y_{t-j}+\sum_{\square=1}^{\square 25}\ \beta_{33j}\Delta Z_{t-k}+\beta_{34}\varepsilon_{t-1}+\mu_{5t},$$

Where $V_t$, Wt, $X_t$, $Y_t$, and $Z_t$ depicts the natural logarithms of the variables, *β' s* represents the parameters to be estimated, *L's* are the number of lags, $\mu_t$*'s* are the serially uncorrelated error terms and $\varepsilon_{t,-1}$*,s* are the error correction term.

### Vector Autoregressive Model (VAR)

The authors review how the VAR model performs the econometric tasks: data description, forecasting, structural inferences, and policy analysis. To do so, we set up a VAR to see how $CO_2$ affects GDP, FDI, REN, and UNB.

The problem associated with VAR includes VARs are theoretical, how to decide the appropriate lag length. Another disadvantage is too many parameters, especially if you have g equations for *g* variables and we have *k* lags of each of the variables in each equation, we have to estimate ($g+kg^2$) parameters. Example: example: $g=3, k=3$, parameters =30.

$$Y_t=a_1+b_{11}y_{t-1}+b_{12}x_{t-1}+u_t$$

$$X_t=a_2+b_{21}y_{t-1}+b_{22}x_{t-1}+v_t$$

Variable $y_t$ and $x_t$ are stationary. $U_t$ and $v_t$ are white noise disturbances. Commonly called innovations or shock terms.

$$Lnco2_t = a+\sum_{\square-1}^{\square}\ \beta_i lnco_{2t-l}+\sum_{\square-1}^{\square}\ \phi_j lnfdi_{t-j}+\sum_{\square=1}^{\square}\ \varphi_m lnren_{t-m}+\sum_{\square=1}^{\square}\ ɰ_n lngdp_{t-n}+\sum_{\square=1}^{\square}\ \lambda_o lnubn_{t-o}+\mu_{1t}$$

$$Lnfdi_t = b+\sum_{\square-1}^{\square}\ \beta_i lnco_{2t-l}+\sum_{\square-1}^{\square}\ \phi_j lnfdi_{t-j}+\sum_{\square=1}^{\square}\ \varphi_m lnren_{t-m}+\sum_{\square=1}^{\square}\ ɰ_n lngdp_{t-n}+\sum_{\square=1}^{\square}\ \lambda_o lnubn_{t-o}+\mu_{2t}$$

$$Lnlren_t = c+\sum_{\square-1}^{\square}\ \beta_i lnco_{2t-i}+\sum_{\square-1}^{\square}\ \phi_j lnfdi_{t-j}+\sum_{\square=1}^{\square}\ \varphi_m lnren_{t-m}+\sum_{\square=1}^{\square}\ ɰ_n lngdp_{t-n}+\sum_{\square=1}^{\square}\ \lambda_o lnubn_{t-o}+\mu_{3t}$$

$$Lngdp_t = d+\sum_{\square-1}^{\square}\ \beta_i lnco_{2t-}+\sum_{\square-1}^{\square}\ \phi_j lnfdi_{t-j}+\sum_{\square=1}^{\square}\ \varphi_m lnren_{t-m}+\sum_{\square=1}^{\square}\ ɰ_n lngdp_{t-n}+\sum_{\square=1}^{\square}\ \lambda_p lnubn_{t-p}+\mu_{4t}$$

Where k=the optimal lag length, a,b,c,d, e = intercept, $Lngdp_t$ = $\beta_i$, $\phi_j$, $\varphi_m$, $ɰ_n \lambda_p$ = short run dynamic coefficients of the model's adjustment long run equilibrium and $\mu_{it}$=residuals in the equation

### Estimation strategy

The following steps are performed to explore the dynamics links between the study variables: REN, FDI GDP, UBN, and $CO_2$. The study used the ADF-fisher, PP- fisher unit root test to analyze whether the variables contain unit root test. The Johansen co integration test is employed to examine whether the variables are co integrated. Pair wise Granger causality is employed to ensure causality. Vector Error-Correction, Vector Autoregressive Model were utilized to determine whether a not short-run and long run link exists among the variables. Lastly, residual test like inverse roots of A.R. characteristics Polynomials was use to check VAR stability.

## Empirical analysis and results: Panel unit root

**Table 1:** Unit root test.

| Variable | Level | | First difference | |
|---|---|---|---|---|
| | Intercept/C | Intercepts & trend/C&T | Intercept/C | Intercept and trend/C&T |
| **ADF-Fisher chi-square** | | | | |
| **Loren** | 92.7363** | 103.558*** | 276.454*** | 208.250*** |
| **LnCo2** | 95.8623** | 230.831*** | 271.834*** | 230.831*** |
| **Lnfdi** | 155.563*** | 129.786*** | 431.040*** | 324.012*** |
| **Lnubn** | 948.014*** | 1163.50*** | 938.930*** | 999.127*** |
| **Lngdp** | 181.492*** | 143.973*** | 460.466*** | 358.507*** |
| **PP- fisher chi-square** | | | | |
| **Loren** | 97.4270*** | 76.8953*** | 474.359*** | 642.706*** |
| **LnCo2** | 74.8006* | 85.6830* | 527.442*** | 839.368*** |
| **Lnfdi** | 317.365*** | 628.905*** | 558.184*** | 3497.94*** |
| **Lnubn** | 518.280*** | 7375.84*** | 548.484*** | 7401.26*** |
| **Lngdp** | 241.656*** | 188.543*** | 739.229*** | 2908.80*** |
| **IPS** | | | | |
| **Lnren** | 0.55076 | -2.66964** | -12.6774*** | -9.94304*** |
| **LnCo2** | 1.05810 | -0.68966 | -12.3210*** | -10.9406*** |
| **Lnfdi** | -7.5993*** | -5.96507*** | -20.8734*** | -17.9223*** |
| **Lnubn** | -45.2706*** | -42.5456*** | -44.9914*** | -40.7961*** |
| **Lngdp** | -8.18410*** | -6.12869*** | 20.080*** | -16.5633*** |

Independently, the panel unit root test was carried out. Automatically the optional lag length was obtained with the SIC-Schwarz information criteria. *, **, *** denotes significance at 10%, 5% and 1% level.

**Table 2:** Panel co integration result.

| Det. Trd. Spec. | Individual intercept | | Individual intercepts and individual trend | | No intercept or trend | |
|---|---|---|---|---|---|---|
| **Alternative Hypothesis: common AR Coefs.(Within-dimensions)** | | | | | | |
| | **Statistics** | **Weighted statistic** | **Statistics** | **Weighted statistic** | **Statistics** | **Weighted statistic** |
| **Panel v-Statistics** | -1.791(0.96) | -1.744(0.96) | -2.020(0.97) | -1.685(0.95) | -1.271(0.89) | -1.324(0.90) |
| **Panel rho-Statistics** | 1.936(0.97) | 1.437(0.92) | 2.977(0.99) | 2.503(0.99) | 1.771(0.93) | 1.502(0.93) |
| **Panel PP-Statistics** | 0.897(0.81) | 0.095(0.53) | 0.767(0.77) | -0.367(0.35) | -0.570(0.28) | -0.570(0.28) |
| **Panel ADF-Statistics** | 4.957(1.00) | 4.633(1.00) | 5.985(1.00) | 5.105(1.00) | 2.175(0.98) | 2.175(0.98) |
| **Alternative Hypothesis: common AR Coefs.(Within-dimensions)** | | | | | | |
| **Panel rho-Statistics** | 2.766(0.99) | | 3.132(0.99) | | 2.949(0.99) | |
| **Panel PP-Statistics** | 0.907(0.81) | | -1.862(0.03) | | -0.696(0.24) | |
| **Panel ADF-Statistics** | 6.315(1.00) | | 4.931(1.00) | | 3.840(0.99) | |

**Note:** P-values are in parenthesis. P-values are significant at significance at 10%, 5% and 1% level. Det., Trd., Spec. denotes Deterministic Trend Specification respectfully.

**Table 3:** Johansson-Fisher and Kao Panel co integration test.

| **Johanson Fisher Panel co integration test** | | | | |
|---|---|---|---|---|
| **Unrestricted co integration rank Test(Trace and Maximum Eigenvalue)** | | | | |
| **No. of C.E. (s)** | **From traced test** | **Prob.** | **From max-eigen test** | **Prob** |
| **None*** | 595.4 | 0.0000 | 407.1 | 0.0000 |
| **At most 1** | 265.7 | 0.0000 | 179.9 | 0.0000 |
| **At most 2** | 129.9 | 0.0000 | 90.03 | 0.0004 |
| **At most 3** | 80.11 | 0.0044 | 65.05 | 0.0748 |
| **At most 4** | 83.06 | 0.0023 | 83.06 | 0.0023 |
| **Kao Residual Co integration Test** | | | | |
| **ADF** | **T-Statistics** | **Prob.** | | |
| | -6.098151 | 0.0000 | | |
| **Residual Variance** | 0.004622 | | | |
| **HAC variance** | 0.004392 | | | |
| **Augmented Dickey-fuller Test Equation.** | | | | |
| | **Coefficient** | **St. Error** | **t-Statistics** | **Prob.** |
| **RESID(-1)** | -0.240618 | 0.022413 | -10.73545 | 0.0000 |
| **D(RESID(-1))** | 0.047658 | 0.034001 | 1.401635 | 0.1614 |
| **R-squared** | 0.240618 | Mean dependent var | -0.004511 | |
| **Adjusted R-squared resid** | 0.127540 | S.D.dependent var | 0.073779 | |
| **S.E.of regression resid** | 0.068913 | Akaike info criterion | -2.509346 | |
| **Sum square resid** | 3.652009 | Schwarz criterion | -2.497290 | |
| **Log-likelihood** | 969.3528 | Hannan-Quinn criterion. | -2.504706 | |
| **Durbin-Watson stat** | 1.963103 | | | |

.*, **, *** denotes significance at 10%, 5% and 1% level. With the Fischer panel, C. test probabilities are computed using asymptotic Chi-square distribution. Johanson co integration test:* Trace test indicates one co integration at the 0.05 level denoting rejection of the Hypothesis at the 0.05 level.*Max-eigen value test indicates one co integration eng(s) at the 0.05 level denotes rejection of the Hypothesis at the 0.05 level. C.E. depicts the co integration Equation.

ADF-Fisher-chi-square, PP-Fisher chi-square, and IPS were used to check for stationary. All three test proves that the variables were stationary at their first difference (See table 1).

After determining that all variables are stationary at first difference, performing the Johansen co integration test was needful. Johanson test is much concerned with identifying long-run relationships. Johanson co integration uses two types of statistics, thus traced and Max Eigen value statistics. The main advantage of Johanson co integration over Engle-Granger (E.G.) co integration is that, E.G., co integration identifies only one co integration equation. On the other hand, Johanson co integration can identify more than one co integration relationship. None* on the Johnson co integration means there is one co integration. Johansson and Kao co integration confirmed the presence

**Table 4:** Estimating Vector Error correction model.

| Variables | Coefficient in ECT | Coefficient of ECT where the variable is dependent | Product=Speed of adjustment |
|---|---|---|---|
| **LnCO$_2$** | 1.000232 | 0.00056 | 0.000560 |
| **LnFDI** | 0.225958 | -2.236505 | -0.50536 |
| **LnGDP** | 5.708195 | -0.00706 | -0.04029 |
| **LnREN** | 0.095735 | -0.00168 | -0.00016 |
| **LnUBN** | 4.975664 | -0.010948 | -0.05447 |

**Note:** Every speed of adjustment is -0.05 or less (more negative, e.g.-0.10). Speed of adjustment measured in percentage Ln FDI: 0.225958*-2.236505=-0.50536 OR -50%

of co integration. We found that the series are co integrated, meaning they exhibited a long-run relationship which is in line with other studies [28,29]. The series are related and can be combined in a linear fashion. Thus, even if there are shocks in the short run, which affect movement in the individual series, they would converge with time in the long run.

Table 4 Carbon dioxide emission recorded a positive speed of adjustment of 0.000560, which is statistically significant. This Positive speed of adjustment product means that our VECM continues to move away from long-run equilibrium after experiencing a shock instead of converging back to it.

**Table 5:** Vector Autoregressive Model (VAR).

| | LNCO2 | LNFDI | LNGDP | LNREN | LNUBN |
|---|---|---|---|---|---|
| **LNCO2(-1)** | 1.028624 | -2.137624 | 0.659735 | -0.345867 | 0.709472 |
| | (0.03487) | (4.66127) | (0.43899) | (0.11917) | (0.08299) |
| | [ 29.4959] | [-0.45859] | [ 1.50284] | [-2.90242] | [ 8.54889] |
| **LNCO2(-2)** | -0.036107 | 7.379980 | -0.705494 | 0.435929 | -0.257471 |
| | (0.05069) | (6.77590) | (0.63815) | (0.17323) | (0.12064) |
| | [-0.71226] | [ 1.08915] | [-1.10553] | [ 2.51654] | [-2.13423] |
| **LNCO2(-3)** | -0.002081 | -4.412929 | -0.132391 | -0.107320 | -0.451637 |
| | (0.03620) | (4.83889) | (0.45572) | (0.12371) | (0.08615) |
| | [-0.05748] | [-0.91197] | [-0.29051] | [-0.86754] | [-5.24231] |
| LNFDI(-1) | 0.000177 | 0.297793 | -0.005700 | -0.000464 | 2.45E-05 |
| | (0.00028) | (0.03764) | (0.00354) | (0.00096) | (0.00067) |
| | [ 0.62806] | [ 7.91240] | [-1.60799] | [-0.48241] | [ 0.03662] |
| **LNFDI(-2)** | 0.000103 | 0.250532 | -0.001851 | 0.000670 | -0.000268 |
| | (0.00029) | (0.03926) | (0.00370) | (0.00100) | (0.00070) |
| | [ 0.35020] | [ 6.38075] | [-0.50046] | [ 0.66731] | [-0.38329] |
| **LNFDI(-3)** | -0.000461 | 0.166805 | -0.011192 | -0.000109 | -0.000259 |
| | (0.00029) | (0.03860) | (0.00364) | (0.00099) | (0.00069) |
| | [-1.59704] | [ 4.32132] | [-3.07852] | [-0.11090] | [-0.37688] |
| **LNGDP(-1)** | 0.001711 | -0.466463 | 0.386768 | 0.018105 | -0.011170 |
| | (0.00302) | (0.40412) | (0.03806) | (0.01033) | (0.00720) |
| | [ 0.56579] | [-1.15427] | [ 10.1622] | [ 1.75242] | [-1.55251] |
| **LNGDP(-2)** | 0.002752 | -0.403218 | 0.005754 | -0.030908 | 0.004383 |
| | (0.00320) | (0.42799) | (0.04031) | (0.01094) | (0.00762) |
| | [ 0.85958] | [-0.94212] | [ 0.14274] | [-2.82480] | [ 0.57515] |
| **LNGDP(-3)** | 0.004083 | -0.329461 | 0.043041 | -0.002294 | -0.018551 |
| | (0.00293) | (0.39184) | (0.03690) | (0.01002) | (0.00698) |
| | [ 1.39287] | [-0.84081] | [ 1.16635] | [-0.22896] | [-2.65920] |
| **LNREN(-1)** | -0.018245 | -0.492397 | -0.411368 | 1.038670 | 0.038825 |
| | (0.01115) | (1.48968) | (0.14030) | (0.03808) | (0.02652) |
| | [-1.63703] | [-0.33054] | [-2.93214] | [ 27.2735] | [ 1.46385] |
| **LNREN(-2)** | 0.002281 | 0.501140 | 0.511946 | -0.054543 | -0.020293 |
| | (0.01582) | (2.11415) | (0.19911) | (0.05405) | (0.03764) |
| | [ 0.14419] | [ 0.23704] | [ 2.57119] | [-1.00915] | [-0.53911] |
| **LNREN(-3)** | 0.016098 | 0.412803 | -0.125366 | -0.021846 | -0.018517 |
| | (0.01084) | (1.44860) | (0.13643) | (0.03703) | (0.02579) |
| | [ 1.48535] | [ 0.28497] | [-0.91892] | [-0.58991] | [-0.71795] |
| **LNUBN(-1)** | -0.008284 | -0.456585 | -0.010744 | -0.006342 | 0.799474 |

| | | | | | |
|---|---|---|---|---|---|
| | (0.01531) | (2.04588) | (0.19268) | (0.05230) | (0.03643) |
| | [-0.54124] | [-0.22317] | [-0.05576] | [-0.12125] | [ 21.9484] |
| **LNUBN(-2)** | 0.028819 | 0.381236 | -0.149137 | -0.003620 | 0.051904 |
| | (0.01961) | (2.62063) | (0.24681) | (0.06700) | (0.04666) |
| | [ 1.46989] | [ 0.14547] | [-0.60426] | [-0.05403] | [ 1.11244] |
| **LNUNB(-3)** | -0.026842 | 0.060353 | 0.084786 | 0.017287 | 0.003524 |
| | (0.01387) | (1.85393) | (0.17460) | (0.04740) | (0.03301) |
| | [-1.93523] | [ 0.03255] | [ 0.48560] | [ 0.36473] | [ 0.10676] |
| **C** | 0.036643 | 0.982788 | 1.360555 | 0.136811 | 0.698755 |
| | (0.02506) | (3.34904) | (0.31541) | (0.08562) | (0.05963) |
| | [ 1.46246] | [ 0.29345] | [ 4.31361] | [ 1.59792] | [ 11.7188] |
| **R-square** | 0.986581 | 0.430876 | 0.315155 | 0.967193 | 0.890784 |
| **Adj.R-square** | 0.986300 | 0.418953 | 0.300808 | 0.966506 | 0.888496 |
| **Sum sq. resids.** | 2.840228 | 50742.48 | 450.0699 | 33.16360 | 16.08476 |
| **S.E.equation** | 0.062983 | 8.418395 | 0.792836 | 0.215216 | 0.149882 |
| **F-statistics** | 3509.464 | 36.13825 | 21.96613 | 1407.256 | 389.3222 |
| **Log-Likelihood** | 993.3310 | -2590.041 | -860.6488 | 93.86095 | 358.6915 |
| Akaike AIC | -2.670303 | 7.120331 | 2.395215 | -0.212735 | -0.936316 |
| Schwarz SC | -2.569849 | 7.220785 | 2.495670 | -0.112281 | -0.835861 |
| Mean dependent | 1.981363 | 8.568648 | 0.745249 | 2.398637 | 4.558872 |
| S.D. dependent | 0.538098 | 11.04393 | 0.948168 | 1.175956 | 0.448855 |
| Determinant resid covariance (of adj.) | | 0.000169 | | | |
| Determinant resid covariance | | 0.000152 | | | |
| Log-likelihood | | -1974.528 | | | |
| Akaike information criterion | | 5.613464 | | | |
| Schwarz criterion | | 6.115735 | | | |

**Note:** standard errors in () & t-statistics in [ ]

Table 5 present the Vector Autoregressive Model (VAR) estimations. Looking at the lag of $CO_2$, we can see that the third lag of lnFDI is statistically significant because it has a statistic's value of -1.59704, which is very close to two even though it is weak. So, we can infer that the third lag of $lnCO_2$ has a short-run causal effect on the lag of foreign direct investment. LnREN at first lag is significant with the value -1.63703. Even though it is weakly significant will have a causal short-run impact on lnFDI. lnUNB at lag three value of -1.93523 is significant, which will also have a short-run causal effect on $lnCO_2$. With the second equation, we observed that lnFDI has a causal short-run causal effect on LNGDP with a statistics value of -1.15427.

In equation three, we realized lnGDP has t-statistics of -1.10553, depicting that GDP has a weak causal effect on $LNCO_2$ at lag two. This finding is in line with other extant studies [11,38, 47]. On the same equation three, at lag one lnGDP recorded -1.60799. Even though the t-statistics is weak, it has a causal effect on FDI at lag one. At lag three, lnGDP indicated a causal effect on lnFDI with a statistics value of -3.07852. LnGDP exhibited a causal effect on lnREN at lag one with a weak t-statistical value of -2.93214. Again, renewable energy consumption displayed a negative causal effect on economic growth at lag two with the statistical value of -2.82480. On the same equation, LnREN showed no causal effect on lnUBN at all the lags. Moreover, at lag one and lag three, lnUBN recorded a statistical value of -1.55251 and -2.65920. Therefore, we can strongly indicate that urbanization has a negative effect on economic growth at lags 1 and 3 in the short run [44,17] .

**Table 6:** VAR lag Order Selection criteria.

| Lag | LogL | LR | FPE | AIC | SC | HQ |
|---|---|---|---|---|---|---|
| **0** | -4203.109 | NA | 2.137192 | 14.94888 | 14.98736 | 14.96390 |
| **1** | -1617.713 | 5115.686 | 0.000240 | 5.853333 | 6.084236* | 5.943474 |
| **2** | -1542.290 | 147.9004 | 0.000200 | 5.674208 | 6.097530 | 5.839465* |
| **3** | -1501.081 | 80.07438 | 0.000189* | 5.616630* | 6.232371 | 5.857004 |
| **4** | -1479.984 | 40.61975 | 0.000192 | 5.630495 | 6.438656 | 5.945987 |
| **5** | -1461.098 | 36.02803 | 0.000196 | 5.652214 | 6.652794 | 6.042823 |
| **6** | -1441.841 | 36.39430 | 0.000200 | 5.672614 | 6.865612 | 6.138339 |
| **7** | -1419.299 | 42.20104 | 0.000202 | 5.681346 | 7.066764 | 6.222188 |
| **8** | -1384.808 | 63.95748* | 0.000195 | 5.647632 | 7.225469 | 6.263592 |

*indicates lag order selected by the criterion.LR: Sequential modified LR test statistics (each test at 5% level). FPE: Final Prediction Error. AIC: Akaike Information Criterion.SC: Schwarz Information Cirterion. HQ: Hannan-Quinn information Criterion.

The rule of thumb, according to table 6, is that the criterion that gives the lowest value is the best fit for the model. The lower the value, the better the model. We can see from table six (6) that AIC recorded 5.616630* and SC recorded 6.084236*. A lag structure will be the best approach to use for the model because it is the criterion with the lowest value. The optimal lag for this structure is three. Having identified the standard that is the best fit for the model with the optimal lag, it was imperative to run the unrestricted VAR model illustrated in Table 5.

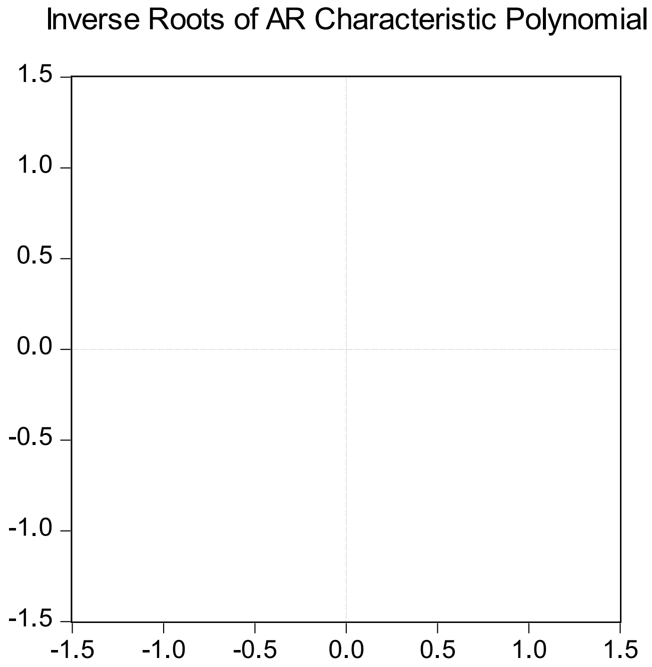

**Figure 3:** Residual test: Inverse roots of A.R. characteristics Polynomials.

We realized from figure three (3) that all inverse roots of the characteristics A.R. polynomials have modulus less than one and lie inside the unit circle; there, the estimate VAR is stable. Meaning the lag selection is perfect. Now that we have stated that our model is stable, we will perform a residual diagnostic. We could also infer from figure 3 diagrams that all the values lay inside two standard error bound, which is a good sign. We can move on to perform a pair wise granger causality test.

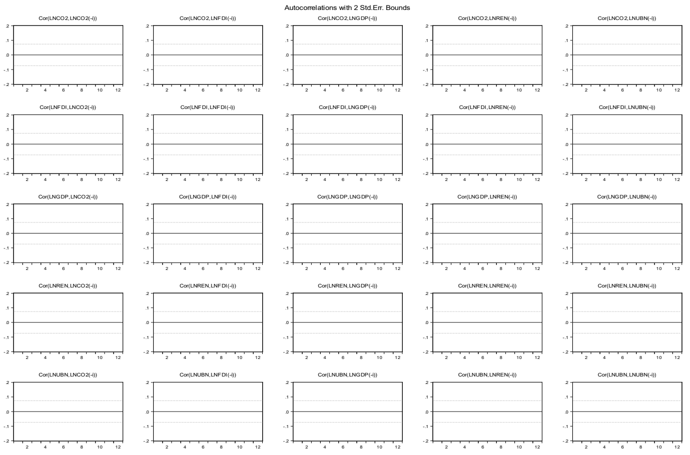

**Figure 4:** Residual diagnostics.

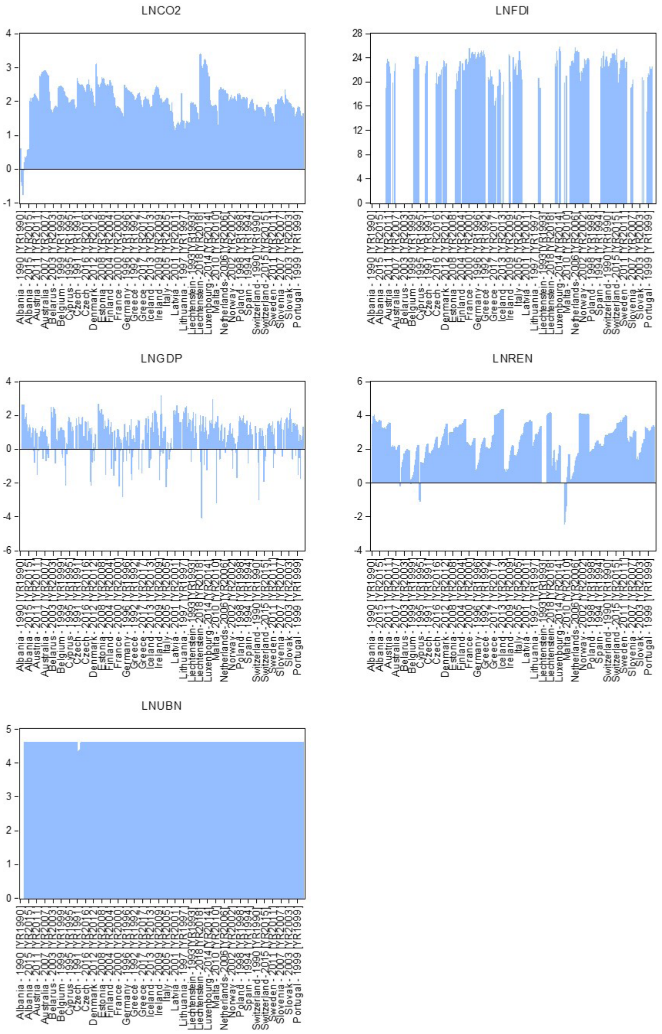

**Figure 5:** Categorical diagrams.

| Null Hypothesis | Obs | F-Statistic | Prob. |
|---|---|---|---|
| LNFDI does not Granger Cause LNCO2 | 804 | 0.23309 | 0.7921 |
| LNCO2 does not Granger Cause LNFDI | | 1.60660 | 0.2012 |
| LNREN does not Granger Cause LNCO2 | 810 | 1.17825 | 0.3083 |
| LNCO2 does not Granger Cause LNREN | | 5.03115 | 0.0067 |
| LNGDP does not Granger Cause LNCO2 | 777 | 4.60903 | 0.0102 |
| LNCO2 does not Granger Cause LNGDP | | 10.0862 | 0.00005 |
| LNUBN does not Granger Cause LNCO2 | 810 | 1.80445 | 0.1652 |
| LNCO2 does not Granger Cause LNUBN | | 41.0439 | 1.E-17 |
| LNREN does not Granger Cause LNFDI | 804 | 0.66186 | 0.5162 |
| LNFDI does not Granger Cause LNREN | | 0.55563 | 0.5739 |
| LNGDP does not Granger Cause LNFDI | 771 | 3.70941 | 0.0249 |
| LNFDI does not Granger Cause LNGDP | | 12.1660 | 0.0006 |
| LNUBN does not Granger Cause LNFDI | 804 | 0.46124 | 0.6307 |
| LNFDI does not Granger Cause LNUBN | | 2.3E-05 | 1.0000 |
| LNUBN does not Granger Cause LNFDI | 804 | 0.46124 | 0.6307 |
| LNFDI does not Granger Cause LNUBN | | 2.3E-05 | 1.0000 |
| LNGDP does not Granger Cause LNREN | 777 | 5.64470 | 0.0037 |
| LNREN does not Granger Cause LNGDP | | 5.38049 | 0.0048 |
| LNUBN does not Granger Cause LNREN | 810 | 0.12102 | 0.8860 |
| LNREN does not Granger Cause LNUBN | | 0.54975 | 0.5773 |
| LNUBN does not Granger Cause LNGDP | 777 | 3.43279 | 0.0328 |
| LNGDP does not Granger Cause LNUBN | | 0.83954 | 0.4323 |

**Table 7:** Pair wise Granger causality tests.

**Table 8:** Data description.

| Variable | Proxy | Sources | Definition |
|---|---|---|---|
| Carbon dioxide emissions (Co2 emissions) | metric tons per capita | WDI | Carbon dioxide emissions are those stemming from the burning of fossil fuels and the manufacture of cement. They include carbon dioxide produced during the consumption of solid, liquid, and gas fuels and gas flaring. |
| Foreign direct investment(FDI) | net (BoP, current US$) | WDI | Foreign direct investments are the net inflows of investment to acquire a lasting management interest (10 percent or more of voting stock) in an enterprise operating in an economy other than that of the investor. It is the sum of equity capital, reinvestment of earnings, other long-term capital, and short-term capital, as shown in the balance of payments. This series shows the total net FDI. In BPM6, financial account balances are calculated as the change in assets minus the change in liabilities. Net FDI outflows are assets, and net FDI inflows are liabilities. Data are in current U.S. dollars. |
| Gross Domestic Product(GDP) | GDP per capita growth (annual %) | WDI | The annual percentage growth rate of GDP per capita is based on constant local currency. Aggregates are based on constant 2010 U.S. dollars. GDP per capita is gross domestic product divided by midyear population. GDP at purchaser's prices is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. |
| Urbanization | Access to electricity, urban (% of urban population) | WDI | Access to electricity, urban is the percentage of urban population with access to electricity. |
| Renewable energy | Renewable energy consumption (% of total final energy consumption) | WDI | Renewable energy consumption is the share of renewable energy in total final energy consumption. |

Again, in seeking to identify the causality relationship between the variables, we employed the Pair wise Granger Causality Tests in table 7. We examined whether the information provided by the lagged values of one variable allows for a more accurate prediction of another present value. Nonetheless, if we found that variable X granger causes variable Y, variable X could be used to predict future movement in variable Y. Decision; if p values are greater than 0.05, we accept Ho. It means no causality. On the other hand, if the p-value is less than 0.05, we reject Ho. It means causality exists. The first Hypothesis says that LNFDI does not Granger cause LNCO$_2$. This means that we cannot reject the null hypothesis because the p-value is more than five percent (0.05%), suggesting that we fail to reject the null hypothesis or accept the null Hypothesis. We found that LNCO2 does not Granger cause LNFDI recorded a p-value of 0.2012. The p-value is 20% which is more than 5%; therefore, we cannot reject the null Hypothesis. Rather, we accept the null Hypothesis, which means that FDI does not cause CO2 emissions [35,50]. The null Hypothesis LNREN does not Granger cause LNCO$_2$ recorded a p-value of 0.3083, which is more than 0.05%, so we cannot reject the null Hypothesis, but rather we accept. Meaning that Renewable energy ensures environmental quality. The fourth null Hypothesis: LNCO$_2$ does not Granger cause LNREN recorded 5.03115 with its p-value of 0.0067. The p-value of 0.0067 is smaller than 0.05%. Therefore, we can reject the null Hypothesis, which means that renewable energy decrease CO$_2$ emissions. We found a unidirectional causality between renewable energy and CO$_2$ emissions, which is in line with other studies [27,42,32,4]. The null hypotheses LNGDP does not Granger cause LNCO$_2$ recorded a p-value of 0.0102, less than 5%. Meaning that the null hypothesis cannot be accepted. P-value of 0.0102 means that economic growth causes CO$_2$ emissions indicating a unidirectional causality [7,49,50]. There was bi-directional causality between CO$_2$ and GDP [51,52,53].The null Hypotheses LNCO$_2$ does not Granger Cause LNUBN had a P-value of 1.017, which is higher than 5%. Therefore, we reject the null hypothesis" LNCO$_2$ does not Granger Cause LNUBN". This means that urbanization causes environmental pollution and agrees with extant studies [29,16,41,43,17] .There exists bi-directional causality between LNFDI and LNGDP. Unidirectional causality existed between urbanization and economic growth among the European countries.

## Conclusion and policy implications

The recent debate across the European Union is to reduce carbon dioxide emissions by 2030 while maintaining rapid economic growth. Achieving this dynamic equilibrium is complicated for countries. Energy demand is rising across E.U. countries, and equivocally conventional energy is still the primary energy source. As a result, finding alternative strategies to minimize carbon dioxide emissions by boosting the share of clean energy in overall energy consumption is crucial for governments. Therefore, this study analyzed the determinant of CO$_2$ emissions by employing four regressors (Renewable energy, foreign direct investment, urbanization, and economic growth) in some selected European countries spanning from 1990 to 2018. The study used ADF-fisher, PP- fisher unit root test to analyze whether the variables contain the unit root test. Causality examination was carried out with Johnson fisher panel, Panel Pedron, Kao co integration, and Pair wise Granger causality. Diagnostic tests were used to ensure that the results were robust and stable. Imperatively, the Vector Error-Correction (VAR**)** model emphasized the direction among the variables.

The result from Pedronicointegration confirmed the presence of co integration. Also, the Kao co integration test confirmed the presence of co integration. The findings from the study showed that VECM continues to move away from long-run equilibrium after experiencing a shock instead of converging back. VAR model confirmed the short-run causal effect among the variables. The A.R. characteristics Polynomials, demonstrated VAR stability. Residual diagnostic performed attested that values lay inside two standard error bound**.** According to the aforementioned facts presented in this study, economic expansion boosted pollution emission amount in the past decades, ceteris paribus (unidirectional causality). The result from Pair wise Granger causality indicates that foreign direct investment contributes to increasing $CO_2$ emissions (unidirectional). Urbanization reduces the quality of the environment. Lastly, renewable energy was found to minimize environmental pollution.

Based on the facts identified in the study, the following policy directions are suggested; Throughout 1990 and 2019, European Union greenhouse gas emission decreased by twenty-four percent, while the economy boomed by sixty percent. Pollution decreased by three point seven percent from 2018 to 2019. The European Union emissions Trading System (EU-ETS) regulated sectors, particularly the power plan, had the biggest drop. Between 2018 and 2019, emissions from stationary installation in all nations covered by the system reduced by 9.1%. Therefore, emissions producer companies with the inability to reduce $CO_2$ emissions should pay more allowances to companies with such capability to ensure continuous aid in advocating for E.U. green deal in the ensuing years. Since renewable energy was found to improve environmental quality, clean energy must be used more frequently, and energy efficiency must be improved. To avoid disastrous climate change urging neighboring countries to do the same should be top priority of European Union because the more E.U. saves others nations, the more E.U. saves itself from environmental pollution immensely.

Moreover, in other for E.U.'s roadmap geared towards climate neutrality by 2050 and its call to reduce $CO_2$ emission by 60% in 2030, clean energy technologies must have their costs slashed further, performance-enhanced, new cutting-edge technologies must also be created. Again, we found that urbanization is a determinant of $CO_2$ emissions. Therefore, to ensure that people continue to reside in rural areas, development should not be aimed at a particular zone. To curb the menace of urbanization on the environment, the E.U. could have policies of making development decentralization a priority. Adding more, the economic cooperation and development founded in 1961 proposed multilateral agreement on foreign direct investment demonstrated how international investment standards might contradict both national and multilateral environmental agreements. Any possible future international investment legislation must eliminate such conflict by adhering to well-established environmental concepts such as the polluter-pays concepts and the precautionary viewpoints.

The study prompted these areas for further studies; more in-depth study should be done on the determinant of environmental pollution hobnobbing with economic growth in E.U. countries. Another study should be conducted on environmental pollution causing urbanization in other countries to replicate the findings of this study. Despite the effort of E.U.'s eager effort to reduce $CO_2$ drastically, E.U. is noted to be responsible for approximately ten percent of world greenhouse gas emissions which is a great minus to E.U. More studies need to be conducted to know whether E.U. policies to tackle $CO_2$ are going catty wampus with current data trends.

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