Pollution 2021, 7(4): 749-767
DOI: 10.22059/POLL.2021.321490.1057

RESEARCH PAPER

Environmental Pollution and Disaggregated Economic Policy Uncertainty: Evidence from Japan

Jamiu Adetola Odugbesan[1,2*] and Sarah Aghazadeh[3]

1. Faculty of Economics, Administrative and Social Sciences, Cyprus West University, North Cyprus, Mersin 10, Turkey
2. Faculty of Political and Social Sciences, Onbes Kasim Kibris University, North Cyprus, Mersin 10, Turkey
3. Faculty of Economics and Administrative Sciences, Final International University, North Cyprus, Mersin 10, Turkey

Received: 05 April 2021, Revised: 17 May 2021, Accepted: 18 September 2021

ABSTRACT
Though, the attention of researchers on exploring the impact of economic policy uncertainty on carbon emissions is on increase, however, the impact of different types of economic policy uncertainty remains unexplored. Thus, this study investigates the impact of different types of economic policy uncertainty on carbon emissions in Japan. A monthly data from 1987M1 to 2019M12 was used, while the FMOLS, DOLS, CCR and ARDL estimators were employed for examining the cointegration among the variables, as well as the long- and short-run relationship between types of economic policy uncertainty and carbon emissions. The study findings revealed a long-run cointegration among energy consumption, per capita income, fiscal, exchange rate, monetary, and trade policy uncertainties and carbon emissions. Moreover, this study found energy consumption, exchange rate, monetary, and trade policy uncertainties to contribute significantly to the increase of carbon emissions in Japan. Finally, this study suggests that environmental policy makers in Japan should take into account the economic policy uncertainty so as to promote robust information for climate policy that will be targeted at ameliorating the carbon emissions in Japan.
Keywords: Environmental pollution; Economic policy uncertainty; Climate change; Environmental quality; Japan

INTRODUCTION

The issue of environmental pollution as being a major concern for both industrialized and developing countries (Adebayo & Odugbesan, 2020; Alola & Kirikkaleli, 2019; Alola & Kirikkaleli, 2021; Alola et al. 2019; Usman, Alola, & Sarkodie, 2020). The negative effect of the greenhouse gasses (GHG) deposition on the earth's surface all around the globe irrespective of who is responsible for the deposition is becoming glaring (Adebayo et al. 2021a, 2021b; Alola, 2019a, 2019b). For instance, the impact of the flood outburst in Pakistan, wildfire in Russia, the earthquake in Haiti, as well as the tsunami in Japan are notable catastrophe witnessed around in the world in recent time and the attendant consequence will be environmental degradation. Moreover, the consequence of these events also reflects on the environmental climate change where the glaciers are diminishing, ice on the streams and rivers are melting off early, most of plants and animal species are going into extinction, and so on. Meanwhile, the anticipated impact from this phenomenon by previous

* Corresponding author Email: odugbesanadetola@gmail.com

researchers is already happening. For instance, “Typhoon Mangkhut’s” passage of 2018 in Philippines has impacted over 250,000 people throughout the region with 59 deaths recorded from the heavy rains. Moreover, in 2019, 8.4 million hectares of land, 1,300 houses, 27 deaths, and over one billion livestock in four months were lost in Australia to wildfire (Adebayo & Odugbesan, 2020). In the case of Japan, a massive floods, extreme weather, and earthquake were recorded in Osaka, while typhoon that destroyed Japan in 2018 occurred in Jebi (Adebayo & Odugbesan, 2020), and led to climate change, loss of 1282 lives and decrease in GDP by 0.64% making Japan to be the most affected nation on earth.

Meanwhile, even though the challenge of environmental pollution is a global one, and the planet is vulnerable to the risks emanating from the degradation of environmental quality, the onus of protecting the earth from these challenges’ rests mostly on the main GHGs emitters’ countries. According to EIA (2020), these countries are China (27.52%), USA (14.81%), India (7.26%), Russia (4.68%), Japan (3.18%), and Germany (2.0%). Therefore, it becomes imperative to have a deeper understanding of CO_2 emissions determinant factors with special interest on the level of economic policy uncertainty (EPU). The interest of researchers on EPU in the recent time has been on increase owing to its impact on economic activity. In this sense, the recessions in the past and present has always has monetary, fiscal or regulatory concerns being associated (Bachmann et al. 2013; Bloom, 2009; Bernanke, 1983; Hassett & Metcalf, 1999). In the recent time, the COVID-19 pandemic has heightened lots of economic uncertainty globally (Altig et al. 2020; Bakas & Triantafyllou, 2020; Baker et al. 2020). Generally, environment in which businesses are being conducted gets affected by EPU which in turn has effect on the decision making of economic entities. This implies that CO2 emissions are linked to the production decisions of businesses, EPU could have impact on CO2 emissions (Jiang et al. 2019). For instance, the EPU indexes (Baker et al. 2013) which was built on an automated search process to track the frequency of mentioning economic policy, uncertainty, and regulatory-related words from major newspaper have been gaining significant traction in uncovering this relationship. Several studies have revealed the significant adverse effect of EPU indexes on economic activity (Baker et al. 2016; Bloom, 2017; Hu & Gong, 2019; Gulen & Ion, 2015; Jiang et al. 2018). The reflection of economic activity in economic growth is expected to be corollary of energy consumption, especially when the country is energy-dependent (Pirgaip & Dincergok, 2020). Meanwhile, according to (Grossman & Krueger, 1995), economic activities and burning of fossil fuels are strongly related to CO_2 emissions. The significant impact of income (GDP per capita) on environmental indicators has been demonstrated in the literature (Shahbaz & Sinha, 2019), meanwhile, the level of environmental pollution in developed countries can reduce by income if the policymakers in these nations can put into consideration the health and other issues that are significant than the level of per capital income or economic performance (Rjoub et al. 2021; Odugbesan et al. 2020). Whereas, the global warming and climate change are as a result of environmental pollution and greenhouse gases which are a threat to the economic growth sustainability both in the advanced economies or emerging economies (Adebayo et al. 2021b; Alola, 2019a; 2019b; Alola et al. 2019; Usman, Alola, & Sarkodie, 2020).

The finding of some studies that argued in reference to the study of Hamilton (1983) demonstrates that energy consumption and EPU may be considered as tightly coupled through energy prices fluctuation triggered by demand and supply shocks in the market and the downside effect expectations on macroeconomic developments which may influence consumer and firm’s decision on energy usage (Adebayo et al. 2021a; Alola & Kirikkaleli, 2019; Aloui et al. 2016; Antonakakis et al. 2014; Degiannakis et al. 2018; Hailemariam et al. 2019; Olanipekun et al. 2019; Usman, Alola, & Sakodie, 2020). The evidence of such significant interrelationship between EPU and CO_2 emissions is possible owing to the works of Appiah (2018) and Salahuddin et al. (2015) for instance who demonstrated that CO_2 emissions are mostly dependent on the energy utilization for the sake of economic growth, even though Baek (2015) and Shabaz et al. (2013) observed that the concomitance is somewhat blurred owing to the recent prioritization of green development in many economies. This perception has been modeled as the "Environmental Kuznets Curve (EKC)" (Grossman & Krueger, 1991; 1995). The EKC hypotheses indicate that higher economic performance will cause an increase in the level of GHGs until the emerging country experiences a specific level of per capita GDP, and then there will be reduction in the GHGs (Adebayo et al. 2021a; Apergis & Ozturk, 2015; Aslan et al. 2018; Rjoub et al. 2021; Shahbaz et al. 2017). In view of this, this study infers the possibility of EPU affecting CO_2 emissions which is in reference to the study of Jiang et al. (2019), Pirgaip & Dincergok (2020), and Wang, Xiao, & Lu (2020) who demonstrates the significant relationship between EPU and CO_2 emissions in their studies. In addition, a deterring impact of EPU over adoption of environmental-friendly technology investment was revealed in the study of Romano & Fumagali (2018), nevertheless, Cai et al. (2018) found the causal links between CO_2 emissions and EPU or energy consumption to be endogenous.

Hence, in this study, EPU is included as new CO_2 determinants in Japan. In other words, the EKC model is extended with the inclusion of EPU and different type of EPU (fiscal policy uncertainty, monetary policy uncertainty, trade policy uncertainty, and exchange rate policy uncertainty) which has not been previously used in any previous studies in this context especially in Japan, with the aim of addressing a possible omitted variable bias which Odugbesan & Rjoub (2020a) posited that it could be addressed with the introduction of new variable among others constitute the novelty of this study. In addition, the study responds to the suggestion of Jiang et al. (2019) who suggested that future study should explore different economic policies uncertainty on carbon emissions as their reaction could be different. The main contributions of this study are as follows: (i) first, the selection of Japan is based on the fact that the country is among the highest GHGs emitters in the world with 3.18% (EIA, 2020). According to Climate Transparency (CT), it was revealed that the Japan's 9.9 emissions per capita presently are above the G20 average of 7.5 per capita (CT, 2021). In addition, the GHGs emissions (1,310MtCO_2e) of Japan as at 2020 are not on the track for a 1.5^{0}C world. Though, the country NDC proposes to limit its emissions to 1,078MtCO_2e by 2030, but under current policies, Japan's emissions are projected to be between 1,082 and 1,144MtCO_2e by 2030 (CT, 2021). Moreover, Japan is the 3rd highest GDP in the world with a GDP of 5.08 trillion U.S. dollars and GDP per capital of US$40,247 as at 2019 (World Bank, 2021). Therefore, this study aims to provide significant policy implications to the country's emissions reduction by providing answers to questions whether there is long-run relationship between the overall EPU and CO_2 emissions, as well as the impact of fiscal policy uncertainty (FPU), monetary policy uncertainty (MPU), trade policy uncertainty (TPU), and exchange rate policy uncertainty (ERPU) on carbon emissions in the country. Second, the investigation of the long-run cointegration among the CO_2 emissions and selected variables with the use of ARDL Bound test which focus on the stable long-run equilibrium. In addition, the long and short-run causal relationship between FPU, MPU, TPU, ERPU, energy use and GDP per capita and CO_2 emissions were investigated. The use of disaggregated EPU is in line with the study of Arbatli et al. (2017) who opined that it is imperative to examine several channels through which uncertainty can affect economic outcomes. To the best of author's knowledge, no previous studies has utilized the different channels of EPU indexes developed by Arbatli et al. (2017) to examine its implication on CO_2 emissions in Japan within the EKC hypothesis. Besides, this study employed ARDL, FMOLS, DOLS, and CCR to examine the long-run relationship of FPU, MPU, TPU, ERPU, energy consumption, and GDP per capita with CO_2 emissions. This study thus addresses the existing gap in the literature.

The issue of climate change which has been a great concern around the world over the years has heightened the number of studies investigating the determinant factors of carbon emissions. The notable hypothesis in this regard is the EKC hypothesis (Kuznet 1955) which postulates an inverted U-shape relationship between economic growth and income inequality indicating certain level of development at which growth-induced inequalities begin to decrease. This hypothesis over the years has been adapted to energy literature for its validation in respect to the relationship between economic growth (income per capita) and the quality of environment. This idea was initiated by Grossman & Krueger (1991), after which several studies have attempted to identify the EKC validity in both country-specific and panel studies. This study is confined to the studies of Mardani et al. (2019), Shahbaz & Sinha (2019), and Stern (2017) for a detailed literature review, out of which it was revealed that the common practice among these studies is modeling the nexus between economic growth and CO_2 emissions to examine whether a similar inverted U-shape relationship is in existence, an indication that an increase in environmental degradation will start reverting back when the per capita income threshold or real output is achieved. Though, it is an incontestable fact that the carbon emission and economic growth link is not peculiar to the EKC hypothesis framework, as the hypothesis is associated with causality between energy utilization and economic growth as well. In this sense, the study of Fodha & Zaghdoud (2010) for instance corroborated the "conservation hypothesis", the "growth hypothesis" was corroborated by Menyah & Wolde-Rufael (2010) and Saboori et al. (2012), as well as the studies of Halicioglu (2009) and Soytas & Sari (2009) which supports "feedback hypothesis", and "neutrality hypothesis" (Richmond & Kaufmann, 2006).

Some recent studies also lend credence to the hypotheses, while some studies failed to establish its validity. For instance, the study of Dogan & Turkekul (2016) investigating the determinant factors of carbon emissions in US using data for the period from 1960 to 2010 failed to establish the significance of energy consumption and urban population as determinant factors for increasing carbon emission, meanwhile, international trade was demonstrated in the study as a determinant factor. Similarly, Dogan and Uzturk (2017) rejected the validity of EKC hypothesis for their study on United State using a data from 1980 to 2014. The study revealed that beside the renewable energy consumption that reduces CO_2 emissions, non-renewable energy increases CO_2 emissions. In addition, some recent studies also failed to establish the validity of EKC hypothesis in some countries like Brazil, China, Canada, India, Norway, and USA (Pata & Aydin, 2020), and South Korea (Koc & Bulus, 2020). However, the study of Shahbaz et al. (2019) demonstrates that energy consumption and foreign direct investments results to increase in carbon emissions, while trade openness reduces carbon emissions. In a similarly vain, another study demonstrated that the relationship between economic growth and CO_2 emissions is negative and opined that an energy efficiency improvement, eco-friendly investments increase and the increase in labor productivity are the main channels driving the negative impact of economic growth on carbon emissions (Alola, 2019a, 2019b; Wang et al. 2019). The support for EKC hypothesis can also be found in study of Ozatac et al. (2017) for Turkey; Bekun et al. (2020) for Nigeria; Leal & Marques (2020) for OECD countries; and Saidi & Mbarek (2017) for 19 emerging countries. The variation is the findings could be as a result of variable omission and choice of econometric methods (Odugbesan & Rjoub, 2020a; 2020b). Moreover, the macroeconomic institutional factor is evident to have been neglected in these studies, whereas it is closely related to carbon emissions.

In reference to the study of Gulen and Ion (2015), investment opportunity can be treated as an economic entity's resource in a situation where it is irreversible. In the event EPU rises, this results to the increase in the net income of "waiting" as the value of holding option increases. But, there will be a decrease in net income of investment when the value of holding option increases which results to the growth of marginal investment cost of economic entities. There is possibility of firm adopting "high-energy" and "low-cost" production method to reverse the expected downtrend of net income owing to EPU. Meanwhile, the investment confidence for high energy consumption production will not be lost by investors as information disclosure is not enough. This theory indicates that as a reflection of macroeconomic institutional factor, there is possibility of EPU affecting the external business environment of economic entities, with the attendant consequence on the decision making of economic entities. Meanwhile, there is a close relationship between carbon emissions and production decisions of macroeconomic entities.

Empirically, several studies have investigated the implication of EPU on FDI and firm's investments (Balcilar et al. 2017; Charles et al. 2018; Chen et al. 2018; Feng et al. 2017; Handley & Limao, 2015; Julio & Yook, 2016; Shahbaz et al. 2017). For instance, the FDI flow from US was found to drop when political uncertainty appears (Julio & Yook, 2016), while the study of Handley & Limao (2015) demonstrated that policy uncertainty had a huge fraction on exporting. Uncertainty indicator based on financial, political, and macroeconomics was established in the study of Charles et al. (2018) and they revealed impact of uncertainty on economic activity. Differently, the impact of EPU on patent application and innovations was demonstrated in the literature (Chen et al. 2018; Wang & Shen, 2016; Zhao & Sun, 2016). In this way it is speculated in this study that EPU may have impact on environmental pollution by impacting the economic activity which includes the stock market, investment and trade, and so on. Adedoyin, Nathaniel, & Adeleye (2020) investigate the role of EPU in the anthropogenic nexus among energy consumption, tourism and economic growth. The study found EPU in addition to tourism and energy consumption to be significant drivers of environmental degradation. In addition, the study concluded that policy uncertainty is really a great deal for energy and environmental policies. A similar study by Adams et al. (2020) that investigate causal relationship among energy consumption, EPU, and CO_2 emissions of resource rich economies using PMG-ARDL revealed a significant relationship between EPU and CO_2, while the panel causality test showed a bi-directional relationship between EPU and CO_2. Moreover, Wang, Xiao, & Lu (2020) found GDP (per capita) to promote carbon emissions in the long-run, as well as the impact of EPU on carbon emissions at the long-run in the United States. Similar study conducted by Pirgaip and Dincergok (2020) exploring the causal relationship between EPU, energy utilization and carbon emissions in G7 countries using panel Granger causality analysis found a unidirectional causality running from EPU to energy consumption in Japan, from EPU to carbon emissions in USA and Germany, and from EPU to both CO_2 and energy consumption in Canada. This finding corroborates the position of Jiang, Zhou, & Lu (2019) who demonstrates the Granger-causality from the EPU to the growth of CO_2 emissions in USA, meanwhile the study concluded that CO_2 emissions are affected by EPU when the growth of CO_2 emissions is in a higher or lower growth period.

Though, several studies have attempted to explore the relationship between the EPU and environmental pollution, but the studies on Japan is scant. On this note we follow the studies of Pirgaip & Dincergok (2020), Jiang et al. (2019), and Wang, Xiao, & Lu (2020) to explore the relationship between EPU and CO_2 within the context of Japan. This study is distinct from these studies owing to the new perspective introduced with the use of different types of economic policy uncertainty indexes developed by Arbatli et al. (2017) for Japan. The novelty of this study lies in the use of fiscal policy uncertainty, monetary policy uncertainty, trade policy uncertainty, and exchange rate policy uncertainty to examine their relationship with carbon emissions which is almost unexplored within the context of environmental pollution literature in Japan, because Jiang et al. (2019) suggested that these different economic policies could react differently with carbon emissions, and filling this gap is the motivation behind this study.

MATERIALS AND METHODS

This study aim is to empirically investigate the nexus between EPU and carbon emissions in Japan. In doing so, the energy consumption was added as a control factor since it has been established in the literature to be among the significant determinant factor of carbon emissions (Adebayo et al. 2021b; Adebayo & Odugbesan, 2020), as well as GDP (per capita income) to control for "income effect" (Wang, Xiao, & Lu, 2020). The study utilizes sample data from 1987 to 2019. The overall EPU index used is in reference to Baker et al. (2016), while the disaggregated EPU indexes (fiscal, monetary, trade, and exchange rate) were the new indexes developed for Japan by Arbatli et al. (2019). Since the EPU data are on monthly basis, while the GDP per capita, energy consumption, and carbon emissions are yearly data, this study converted the yearly data to monthly so as to be on the same frequency with EPU data. While the overall EPU, FPU, MPU, TPU, and ERPU were sourced from Arbatli et al. (2019), the data for energy consumption and CO_2 emissions were sourced from the "BP Statistical Review of World Energy (2021). The dependent variable in this study is the CO_2 emissions (metric tons) per capita (CO_2), while the explanatory variables are GDP per capita (measured by real 2010 USD prices) (GDP) and sourced from WDI (2021); the energy consumption (EC); and, the overall EPU (EPUI) as well as fiscal EPU (FPUI), monetary EPU (MPUI), trade EPU (TPUI), and exchange rate (ERPUI) which capture the channels of EPU as highlighted in Arbatli et al. (2017). The overall EPU and disaggregated indexes were captured in different model for a better analysis and the descriptive statistics for the variables are presented in Table 1. All the variables were converted to logarithm form prior to the estimation.

Table 1. Descriptive Statistics

Variable	Mean	Max.	Min.	Std. Dev.
CO_2	9.23	9.89	7.01	0.53
EC	3732.62	4094.74	2926.60	277.98
EPUI	101.94	240.23	48.37	33.54
ERPUI	97.54	610.51	53.30	54.06
FPUI	99.81	332.45	42.36	42.96
GDP_per capita	42717.46	49429.77	31693.87	3891.752
MPUI	103.29	401.02	17.79	52.13
TPUI	129.17	718.45	10.24	113.70

The EKC model is considered in this study in references to the literature (Narayan et al. 2016; Peng et al. 2016; Wang et al. 2020) with the aim of exploring the drivers of CO_2 emissions in Japan. The energy consumption and GDP per capita income were added being a significant determinants of carbon emission, and then suggest EPU as also a driver of carbon emissions. In doing so, three models (Eq. 1, 2, 3) were developed and utilize the following function for an extended EKC model:

$$lnCO_{2t} = f(lnEC_{2t}, lnGDP_t, EPU_t) \quad (1)$$

$$lnCO_{2t} = f(ERPUI_t, PUI_t, MPUI_t, TPUI_t) \quad (2)$$

$$lnCO_{2t} = f(lnEC_{2t}, lnGDP_t, ERPUI_t, FPUI_t, MPUI_t, TPUI_t) \quad (3)$$

The Eq. (1, 2, 3) can be written in econometric model as follows:

$$lnCO_{2t} = \beta_0 + \beta_1 lnEC_t + \beta_2 EPUI_t + \beta_3 lnGDP_t + \varepsilon_t \quad (4)$$

$$lnCO_{2t} = \beta_0 + \beta_1 ERPUI_t + \beta_2 FPUI_t + \beta_3 MPUI_t + \beta_4 TPUI_t + \varepsilon_t \quad (5)$$

$$lnCO_{2t} = \beta_0 + \beta_1 lnEC_t + \beta_2 lnGDP_t + \beta_3 ERPUI_t + \beta_4 FPUI_t + \beta_5 MPUI_t + \beta_6 TPUI_t + \varepsilon_t \quad (6)$$

where $lnCO_2$ denotes carbon emissions, lnEC is the energy consumption, lnGDP is the per capita income, EPUI is the overall economic policy uncertainty, ERPUI is the exchange rate policy uncertainty, FPUI is the fiscal policy uncertainty, MPUI is the monetary policy uncertainty, TPUI is the trade policy uncertainty, while "t", "β", and ε denotes time (1987M1-2019M12), parameters and error term respectively.

In reference to previous studies, it is expected in this that the parameters for energy consumption and per capita income (β_1 and β_2) in Equations 4 and 6 to be > 0 since it was demonstrated in the EKC hypothesis that energy consumption and income effect on CO_2 emissions should be a positive. Meanwhile, the effect of EPU on carbon emissions could either be positive or negative. This according to Wang et al. (2020) is owing to the issue that "energy-intensive products and energy investments" are included in an open economy. Hence, an increase in EPU could results to a reduction in the consumption of energy and "pollution-intensive products" and then lead to reduction of carbon emissions. This effect is tagged "consumption effect", but when an increase in EPU reduce the investment in eco-friendly energy and renewable energy projects, it would cause and increase in carbon emissions, and the effect is tagged "investment effect". In essence, the impact of EPU on carbon emissions lies on the dominant of either "consumption effect" or "investment effect".

The estimation in this study follows three-stage procedures. First, the series order of integration was examined using Zivot-Andrew unit root test (Zivot & Andrews, 2002) which gives account of structural break in the series. At the second stage, the cointegration among the variables was examined using ARDL Bound test (Odugbesan & Rjoub, 2019; Pesaran et al. 2001). Thirdly, the long run relationship between the dependent variable and explanatory variables was examined using "Fully-modified OLS" (FMOLS), "Dynamic OLS" (DOLS", and "Canonical Cointegrating Regression' (CCR). Meanwhile, due to the limitation of these estimators in estimating short-run relationship, "Autoregressive Distributed lag" (ARDL) estimator was applied to estimate both the long-and short-run coefficients in Equation (6) as well as infer the causal relationship as suggested by Pesaran et al. (2001).

The Zivot-Andrews unit root test (Zivot & Andrews, 2002) was utilized in this study to examine the stationarity properties of the data series. This type of unit root test was used owing to its capability of detecting the presence of a structural break. Lee & Strazicich (2003) opined that the examination of structural breaks in the data series enables researchers to avoid the spurious rejection and bias. In view of this, the following model was developed by Zivot

& Andrews (2002) for detecting stationary property of series in the presence of structural break:

Model I: $\Delta_y = \partial + \hat{u}y_{t-1} + \beta t + \gamma DU_t + \sum_{j=1}^{t} d_j \Delta y_{t-j} + \varepsilon_t$ (7)

Model II: $\Delta_y = \partial + \hat{u}y_{t-1} + \beta t + \varphi DT_t + \sum_{j=1}^{t} d_j \Delta y_{t-j} + \varepsilon_t$ (8)

Model III: $\Delta_y = \partial + \hat{u}y_{t-1} + \beta t + \varphi DT_t \gamma DU_t + \sum_{j=1}^{t} d_j \Delta y_{t-j} + \varepsilon_t$ (9)

where the dummy variable for a mean change which occurred on individual potential time break (TB) is denoted with DU_t, while the shift in trend of the variables utilized is represented with DT_t. Formally,

$$DU_t = \begin{cases} 1 \ldots\ldots\ldots if\ t > TB \\ 0 \ldots\ldots\ldots otherwise \end{cases} and\ DU_t = \begin{cases} t - TB \ldots\ldots if\ t > TB \\ 0 \ldots\ldots\ldots\ otherwise \end{cases} \quad (10)$$

This study employed the ARDL bounds test (Pesaran et al. 2001) to examine the possibility of long-term cointegration among the variables employed in the study, owing to its numerous advantages over other traditional cointegration methods that has been alluded in different studies (Adebayo et al. 2021a; Adebayo and Odugbesan, 2020; Odugbesan and Rjoub, 2019; 2020b; Rjoub et al. 2021; Usman, Alola, & Sarkodie, 2020). First, it is appropriate to utilized when the variables order of integration are mixed (i.e I(0) and I(1))). Secondly, it is efficient when the sample is small. Another merit is the impartial evaluation of long-term relationship. The ARDL bound test indicates a long-run cointegration among the variables when the F-statistics is greater than the lower and upper values of the I(0) and I(1) respectively. In line with Pesaran et al. (2001), the ARDL bound test for this study is expressed as follows:

$$y_t = \gamma_{0i} + \sum_{i=1}^{p} \delta_i y_{t-i} + \sum_{i=0}^{q} \beta_i x_{t-i} + \varepsilon_{it} \quad (11)$$

where y_t is a vector and the variables in x_t are allowed to be either I(0) or I(1), or both; the coefficients are denoted with β and δ, the constant is denoted with γ, while I = 1,…,k; p and q are optimal lag orders, and ε_{it} is the error term.

In order to achieve the study aim, we employed the FMOLS, DOLS, CCR and complemented with ARDL error correction framework to examine the long and short-run relationship simultaneously. The FMOLS was proposed by Phillips & Hansen (1990) which employs a semi-parametric correction to remove the challenges arises from the long-run correlation between the cointegrating equation and stochastic regressors innovations. Phillips & Hansen (1990) asserts that the result from FMOLS estimator is “asymptotically unbiased” and has fully efficient mixture of normal asymptotic which allows for standard “Wald test” through the use of “asymptotic chi-square” statistical inference. According to Phillips & Hansen (1990), the FMOLS can be expressed as follows:

Let Ω and ∀ be the long-run covariance matrices which are computed from the residuals $u_t = (u_{1t}, u'_{2t})'$ which is assumed to be the innovation. Hence, the study modified data may be defined as follows:

$$y_t^+ = y_t - \widehat{\omega}_{12} \widehat{\Omega}_{22}^{-1} u_2 \quad (12)$$

and an estimated bias correction term can be written as:

$$\lambda_{12}^{+} = \lambda_{12} - \hat{\omega}_{12}\hat{\Omega}_{22}^{-1}\forall_{22} \tag{13}$$

Thus, FMOLS estimator is given as:

$$\hat{\theta} = \begin{bmatrix}\beta \\ \hat{\gamma}_1\end{bmatrix} = \left(\sum_{t=2}^{T} Z_t Z_t'\right)^{-1}\left(\sum_{t=2}^{T} Z_t Z_t^{+} - T\begin{bmatrix}\lambda_{12}^{+} \\ 0\end{bmatrix}\right) \tag{14}$$

where $Z_t = (X_t', D_t')'$ are deterministic trend regressors.

Meanwhile, the CCR developed by Park (1992) is closely related to FMOLS; however, the estimator employs stationary transformation of the (y_{1t}, X_t') data for obtaining least squares estimates in order to eliminate the long run dependence between the cointegration equation and stochastic regressors innovations. Similar to FMOLS, the estimation using CCR follow a mixture normal distribution which devoid of non-scalar nuisance parameters and allows asymptotic chi-square testing. The estimation in CCR involves obtaining the innovations $u_t = (u_{1t}, u_{2t}')'$ and the corresponding consistent estimates of the long-run covariance matrices Ω and∀. Different from FMOLS and DOLS, CCR requires a consistent estimator of contemporaneous covariance matrix$\hat{\Sigma}$. In line with Park (1992), the matrix column for ∀ that is corresponding to the on-sided long-run covariance matrix of u_t and (the levels and lags of)u_{2t} can be written as :

$$\forall_2 = \begin{bmatrix}\forall_{12} \\ \forall_{22}\end{bmatrix} \tag{15}$$

and transform the (y_{it}, X_t') using

$$X_t^{*} = X_t - \left(\hat{\Sigma}^{-1}\forall_2\right)' u_t$$

$$y_t^{*} = y_t - \left(\hat{\Sigma}^{-1}\forall_2\hat{\beta} + \begin{bmatrix}0 \\ \hat{\Omega}_{22}^{-1}\hat{\omega}_{21}\end{bmatrix}\right)' u_t \tag{16}$$

where$\hat{\beta}$ are estimates of the cointegration equation coefficients. Thus, the CCR estimator is expressed as OLS applied to the transformed data:

$$\begin{bmatrix}\beta \\ \hat{\gamma}_1\end{bmatrix} = \left(\sum_{t=1}^{T} Z_t^{*} Z_t^{*\prime}\right)^{-1} \sum_{t=1}^{T} Z_t^{*} y_t^{*} \tag{17}$$

where$Z_t^{*} = (Z_t^{*\prime},\ D_{1t}')'$

Moreover, it was asserted by Park (1992) that transformations asymptotically of CCR remove the endogeneity that arises from the long-run correlation of the cointegration equation errors and the stochastic regressors innovations, in addition to the correction of asymptotic bias that emanates from the contemporaneous correlation between the regression and stochastic regressor errors. The study then concludes that the estimates from CCR is efficient and is devoid of bias as FMOLS and DOLS. Therefore, justify the choice of the three estimators in this study.

Meanwhile, the FMOLS, DOLS and CCR can only estimates the long-run parameters

(Alola et al. 2019), but in order to estimate the short-run parameters, this study utilized ARDL error correction model.

According to Pesaran et al. (2001), where cointegration is established among variables, the ARDL error correction model can be written as an expansion to Equation (3) as follows:

$$y_t = \gamma_{0i} + \sum_{i=1}^{p} \delta_i y_{t-i} + \sum_{i=0}^{q} \beta_i x_{t-i} + \lambda ECT_{t-1}\varepsilon_{it} \tag{18}$$

Finally, the residual and stability diagnostic of the model will be conducted using "Breusch- Godfrey serial correlation LM" test and "Breusch-Pagan-Godfrey heteroskedasticity" test to check the serial correlation and heteroskedasticity problem respectively. In addition, Jacque-Bera normality test will be employed to check the series normality, while "cumulative sum of recursive residuals (CUSUM)" will be employed to check the model stability in line with previous studies (Adebayo and Odugbesan, 2020; Adebayo et al. 2021b; Odugbesan and Rjoub, 2019; 2020a).

RESULTS AND DISCUSSION

As indicated in the previous section, the study analysis starts with the examination of series stationary property using the Zivot-Andrews unit root test which can detect the structural break point and the result is presented in Table 2. The result indicates that CO_2, EC, EPUI, ERPUI, FPUI, GDP, MPUI are stationary at level with different structural break point, while TPUI becomes stationary after first differencing. It is evident from the unit root test for the series presented in Table that the variables have mixed order of integration and none of them is I(2), hence none of the variable could lose its predictive power and devoid of spurious rejection and bias.

Table 2. Zivot-Andrews Unit Root test with structural break

	Level		1st Diff.		
Variable	**Intercept and Trend**	**Break Point**	**Intercept and Trend**	**Break Point**	**Order of Integration**
CO2	-4.34**	2007M02	-	-	I(0)
EC	-3.81***	2010M02	-	-	I(0)
EPUI	-5.24**	1998M11	-	-	I(0)
ERPUI	-13.92***	2010M08	-	-	I(0)
FPUI	-5.69**	2008M08	-	-	I(0)
GDP	-5.13**	2008M02	-	-	I(0)
MPUI	-6.43**	2010M05	-	-	I(0)
TPUI	-5.74	2008M08	-5.84***	2008M09	I(1)

Subsequently, the long-run cointegration among the variables was examined using the ARDL bound test (Pesaran et al. 2001). The result as presented in Table reveal the F-statistic to be 7.65 which is greater than the lower bound I(0) and upper bound I(1) at 10%, 5%, 0.25% and 1%. Therefore, in reference to previous studies, the null hypothesis of no cointegration should be rejected when the F-statistic is greater than the lower and upper bound respectively (Odugbesan & Rjoub, 2019; 2020a; Pesaran et al. 2001), hence the null hypothesis is rejected in this study and conclude that there is evidence of long-run cointegration among the variables in this study.

Table 3. ARDL Bound Test Cointegration

Model Estimated	Lag Length	F-Statistics	Cointegration
$lnCO_2$=f(lnEN, ERPUI, FPUI, lnGDP, MPUI, TPUI)	(1,1,0,0,1,4,0)	7.65	Yes
Sig. level	Lower Bound I(0)	Upper Bound I(1)	
0.1	2.12	3.23	
0.05	2.45	3.61	
0.025	2.75	3.99	
0.01	3.15	4.43	

Moreover, the long-run relationship between lnCO2 and lnEC, EPUI, lnGDP was examined in model 1 using FMOLS, DOLS, and CCR and the result is presented in Table 4. From the summarized results in column 1, 2, 3, the three estimators confirmed the long-run relationship between energy consumption, economic policy uncertainty, GDP per capita and carbon emissions. Meanwhile, energy consumption and per capita income were found to have positive and significant long-run relationship with carbon emissions at less than 1% confidence level, while economic policy uncertainty shows a negative and significant long-run relationship with CO_2 at 5% confidence level. The negative and significance of the EPUI coefficient in this study is not surprising as it is in congruent with the position of Wang et al. (2020) who opined that the coefficient could either be positive or negative. In addition, some previous studies like Adedoyin et al. (2020), Adams et al. (2020), Pirgaip & Dincergok (2020), and Wang et al. (2020) established similar findings in their studies. The relationship between the different economic policy uncertainties and carbon emission was examined in model 2 excluding the energy consumption and per capita income to ascertain how the different economic policies react with CO_2 emissions. The results as presented in Table 4 column 4, 5 & 6 for each of the estimator shows that exchange rate policy uncertainty (ERPU) and trade policy uncertainty (TPU) have a negative and significant long-run relationship with CO_2 emissions and are significant at 5% and 1% confidence level respectively, while monetary policy uncertainty (MPU) has a positive and significant long-run relationship with CO_2 at less than 1% confidence level for all the three estimators. In model 3, the energy consumption and per capita income together with different economic policy uncertainties impact on CO_2 emissions was investigated and the result was presented in Table 3 column 7, 8, 9, & 10. Based on the estimates from FMOLS, DOLS, and CCR, the positive and significant long-run relationship of energy consumption and per capita income with CO_2 emissions are not different from previous estimates. Meanwhile, only fiscal policy uncertainty (FPUI) was found to have a negative and significant long-run relationship with CO_2 at 5% confidence level.

The estimates from ARDL revealed slightly different results from the FMOLS, DOLS, and CCR as the estimates presented in Table 4 column 10 shows that energy consumption has a positive and significant relationship with carbon emissions. In reference to Pesaran et al. (2001), the causal relationship can be inferred from the estimates and as such the positive parameter of energy consumption indicates a positive and significant causal relationship with CO_2 emissions. This implies that increase in energy consumption trigger the increase in carbon emissions in Japan. The findings support the study of Adebayo & Odugbesan (2020), Bekun et al. (2020), Ozatac et al. (2020), and Shahbaz et al. (2020), Meanwhile, it contrasts the position of some studies who failed to establish a significant relationship between energy consumption and carbon emissions (Dogan & Turkeku, 2016; Dogan & Uzturk, 2017; Koc & Bulus, 2020; Pata

& Aydin, 2020). In addition, the result shows further that exchange rate policy uncertainty (ERPUI) has a positive and significant causal relationship with CO_2 emissions. This implies that in exchange rate policy uncertainty will trigger carbon emission which is significant at 10% confidence level. Similarly, this study findings shows that monetary policy uncertainty (MPUI) and trade policy uncertainty (TPUI) have a positive and significant causal relationship with carbon emissions and it implies that and upward changes in monetary policy uncertainty and trade policy uncertainty will increase the carbon emissions significantly at 5% and 10% confidence level. The positive parameter is an indication that the exchange rate, monetary and trade policies uncertainty are having investment effect on the carbon emissions. These types of policies uncertainty are deterring the investors to invest on eco-friendly technology that could contribute to the amelioration of carbon emissions in the country.

Moreover, ARDL estimator has the capacity of estimating both the short- and long-run causal relationship simultaneously as well as the "error correction term" that will indicate the ability of the model to return back to equilibrium in case of shock that could cause disequilibrium (Odugbesan & Rjoub, 2019; 2020a; Pesaran et al. 2001). In view of this, the short-run estimates and the ECT coefficients are presented in the lower part of Table 4. The ECT coefficient according to Odugbesan & Rjoub (2019) must be negative and significant to indicate the model ability to return to equilibrium. The ECT coefficient presented in Table 4 is negative and significant at less than 1% confidence level which is an indication that in case of disequilibrium, the model 3 has the potential of returning to equilibrium at the adjustment speed rate of 0.02%. In addition, the significance of the ECT coefficient indicates the stable long-run relationship of exchange rate policy uncertainty, monetary policy uncertainty and trade policy uncertainty with carbon emissions in Japan. Finally, the result from the short-run estimates confirms only the energy consumption and per capita income significant causal relationship with CO_2 emissions in the short-run.

Table 4. long- and Short- run relationship estimates

	Model 1			**Model 2**			**Model 3**			
	Long-Run Estimates									
Variable	**FMOLS**	**DOLS**	**CCR**	**FMOLS**	**DOLS**	**CCR**	**FMOLS**	**DOLS**	**CCR**	**ARDL**
lnEC	0.46***	0.508***	0.508***				0.515***	0.515***	0.515***	1.09**
EPUI	-0.023**	-0.02**	-0.015**							
ERPUI				-0.43**	-0.056**	-0.072**	0.03	0.045	0.044	0.14*
FPUI				-0.022	-0.015	-0.026	-0.034**	-0.032**	-0.026**	0.008
lnGDP	0.33***	0.33***	0.33***				0.30****	0.29***	0.29***	-0.20
MPUI				0.08***	0.08***	0.08***	0.01	0.01	0.01	0.17**
TPUI				-0.04***	-0.04***	-0.04***	0.01	0.01	0.01	0.05*
	Short-Run Estimates									
ECT										-0.01***
ΔlnEC										0.26***
ΔERPUI										0.001
ΔFPUI										-0.003
ΔlnGDP										1.01***
ΔMPUI										-0.001
ΔTPUI										-0.001
Serial Corr.										0.430
Hetero										0.158

Normality	0.390

Note: *, **, *** denotes 1%, 5% and 10% confidence level respectively

Subsequent to the model estimation, the residual and stability diagnostic of the model was conducted and the results presented in Table 4 and Figure 1. The diagnostic of serial correlation was conducted using "Breusch-Godfrey serial correlation LM test in line with previous studies (Adebayo and Odugbesan, 2020; Adebayo et al. 2021a; Odugbesan and Rjoub, 2019; 2020a; 2020b) and the result as presented in Table 4 reveal that the p-value (0.650) is greater than 0.05, hence we failed to reject the null hypothesis and conclude that there is no serial correlation issue with the model. Similarly, Breusch-Pagan-Godfrey heteroskedasticity test was utilized to check for heteroskedasticity issue and the result in Table shows that the p-value (0.098) is higher than 0.05 and as such we failed to reject the null hypothesis and conclude that there is no heteroskedasticity issue with the model. As for the normality, the Jacque-Bera normality test was employed and the result shows a p-value greater than 0.05, hence we failed to reject the null hypothesis and conclude that there is normality in the distribution of the series. The model stability is diagnosed using the CUSUM and the CUSUM sum of square and the result is presented in Figure 1 and 2. The figures shows that the CUSUM lines are within the threshold of 5% significance which is an indication of the model stability (Adebayo and Odugbesan, 2020; Adebayo et al. 2021a; Odugbesan and Rjoub, 2019; 2020a).

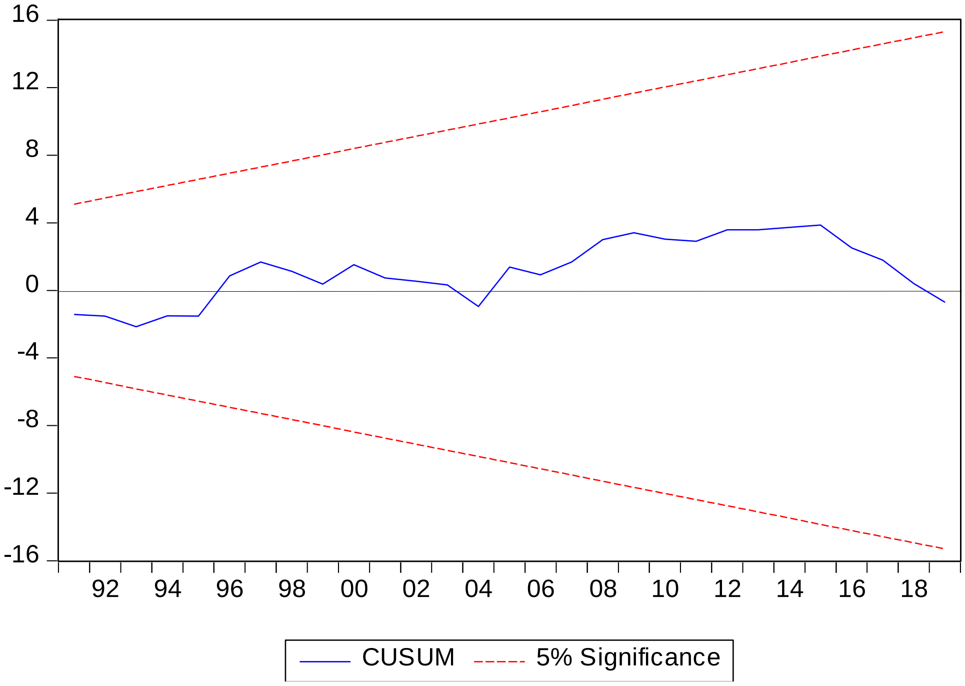

Figure 1a. Model Stability Graph (CUSUM)

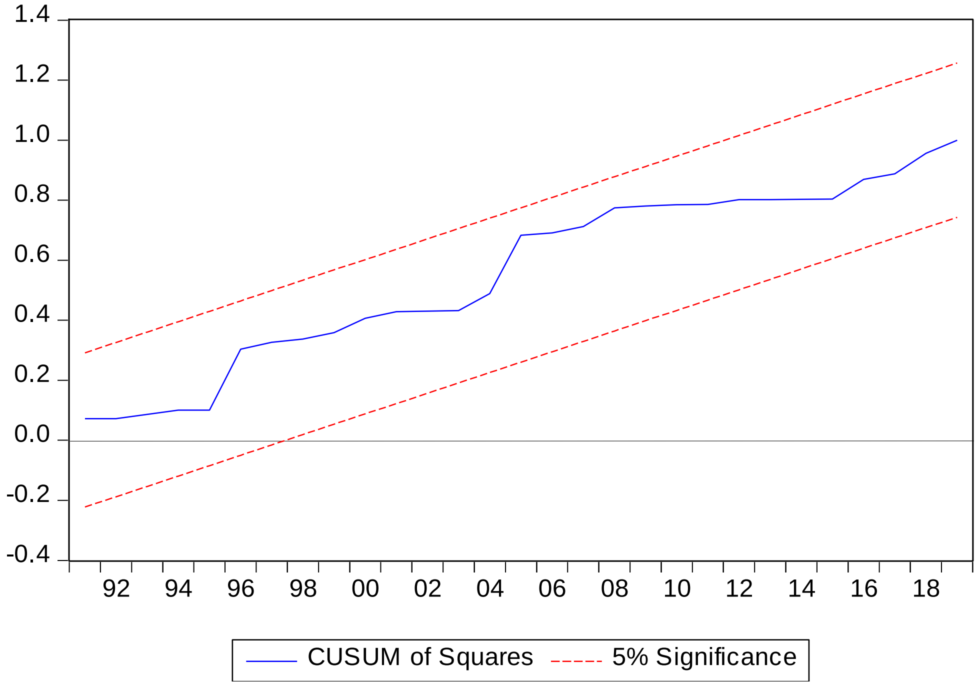

Figure 1b. Model Stability Graph (CUSUM sum of Square)

CONCLUSIONS

This study explored the impact of energy consumption, per capita income, overall economic policy uncertainty, and different economic policy uncertainty (fiscal, exchange rate, monetary and trade) on carbon emissions in Japan. In order to achieve the study aim, three models were developed. The impact of overall EPU, energy consumption and per capita income on carbon emissions was examined with model 1. Model 2 consist of the impact of fiscal, exchange rate, monetary and trade policy uncertainty on carbon emissions, while model 3 examine the impact of all the different types of economic policy uncertainty, energy consumption and per capita income on carbon emissions. The long-run relationship estimates were based on FMOLS, DOLS, and CCR, while the causal relationship estimate was based on ARDL estimator. The result from model 1 suggests that energy consumption, per capita income and overall EPU have a long-run relationship with CO_2 emissions. Model 2 demonstrates that exchange rate, monetary, and trade policy uncertainties have a significant long-run relationship with carbon emissions in Japan. The result implies that while exchange rate and trade policy uncertainties have “consumption effect” on carbon emissions, monetary policy uncertainty has “investment effect” (Wang et al. 2020). In respect of model 3, while FMOLS, DOLS and CCR confirms fiscal policy uncertainty together with energy consumption and per capita income to have long-run relationship with CO_2 emissions, ARDL confirm exchange rate, monetary, and trade policy uncertainties together with energy consumption impact on CO_2 emissions. In addition, the ECT coefficient indicates that in case of disequilibrium, the model has the potential of returning back to equilibrium. Based on the literature and findings of this study, the main policy implications are as follows.

The cointegration test revealed a long-run relationship for all variables and the findings from model 1 and 3 uncovers the adverse effects of energy consumption and per capita income on carbon emissions in Japan in the long-run. These findings are in congruent with previous studies who demonstrated similar findings and concluded that the increase in income is associated with a higher standard of living which results to demand for more energy consumption products and the attendant consequence on carbon emissions (Adebayo & Odugbesan, 2020; Bekun et al. 2020; Ozatac et al. 2020; Shahbaz et al. 2019). Accordingly, the government of Japan should intensify more efforts to promote the use of renewable energy. The achievement of these will require more investment in R & D to improve the necessary technology promotion with the aim of developing and designing more efficient energy systems to decouple economic growth from pollution of environment. Meanwhile, the policymakers should exercise caution in the implementation of carbon emissions conservation or energy consumption policies in such a way that it would not have adverse implications on the economic growth, as well as the consequence on the EPU.

Moreover, the positive coefficient of exchange rate, monetary, and trade policy uncertainties does not come as a surprise. In reference to Wang et al. (2020), the parameter could be either negative or positive. The findings from this study are an indication that the exchange rate, trade and monetary policy uncertainties will deter capital investment in eco-friendly machinery and innovation which are capable of reducing carbon emissions. Thus, it becomes imperative for Japan to promote exchange, trade and monetary policies that will encourage innovations and stimulate capital investment in eco-friendly equipment. In addition, the dynamism of the components of EPU should not be ignored, as this study suggest that a direct impact of EPU will trigger an increase in carbon emissions. In this case, it becomes imperative for the policymakers to formulate policies that would ensure decrease in EPU with the potential of addressing environmental concerns that could emanated.

In relation to the second point, the policy maker should understand that their decisions and actions have tangible ramifications for CO_2 emissions behavior, and as such maintaining stable economic policies should be sacrosanct, especially climate policies and this could promote their carbon reduction targets realization. Finally, the Japan environmental policy makers should take into account the economic policy uncertainty so as to promote robust information for climate policy that will be targeted at ameliorating the carbon emissions in the country.

Though, this study has made significant contributions to the environmental pollution literature, but has some limitations which lies in the country-specific nature of the study, thus, future study can expand the scope and investigate the model in a panel study. In addition, the direction of the causal relationship between the different types of economic policy uncertainty was not investigated in this study; therefore, the investigation of the direction of the different types of economic policy uncertainty with carbon emission will be interesting. Nevertheless, the findings of this study have made significant contributions that would guide the environmental policy makers especially in Japan and countries of similar characteristics, and scholars to understand the reaction of different types of economic policy uncertainty to carbon emissions.

GRANT SUPPORT

The present research did not receive any financial support

CONFLICT OF INTEREST

The authors declares that there is not any conflict of interest regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/ or falsification, double publication and/or submission, and redundancy has been completely observed by the author.

LIFE SCIENCE REPORTING

No life science threat was practices in this research

REFERENCES

Adams, S., Adedoyin, F., Olaniran, E. and Bekun, F. V. (2020). Energy consumption, economic policy uncertainty and carbon emissions; causality evidence from resource rich economies. *Econ. Analy. Pol. 68*, 179-190.

Adebayo, T. S. and Odugbesan, J. A. (2020). Modeling CO2 emissions in South Africa: empirical evidence from ARDL based bounds and wavelet coherence techniques. Environ. Sci. Pollut. Res. 1-13.

Adebayo, T. S., Akinsola, G. D., Odugbesan, J. A. and Olanrewaju, V. O. (2021a). Determinants of Environmental Degradation in Thailand: Empirical Evidence from ARDL and Wavelet Coherence Approaches. Pollution, 7(1), 181-196.

Adebayo, T. S., Awosusi, A. A., Odugbesan, J. A., Akinsola, G. D., Wong, W. K. and Rjoub, H. (2021b). Sustainability of energy-induced growth nexus in Brazil: do carbon emissions and urbanization matter?. Sustainability, 13(8), 4371.

Adedoyin, F. F., Nathaniel, S. and Adeleye, N. (2020). An investigation into the anthropogenic nexus among consumption of energy, tourism, and economic growth: do economic policy uncertainties matter?. Environ. Sci. Pollut. Res. 1-13.

Ahir, H., Bloom, N. and Furceri, D. (2018). The world uncertainty index. SSRN Electron. J. http://dx.doi.org/10.2139/ssrn.3275033. http://www.policyuncertainty.com

Alola, A. A. and Kirikkaleli, D. (2021). Global evidence of time-frequency dependency of temperature and environmental quality from a wavelet coherence approach. Air Qlty, Atm. Hlth, 14(4), 581-589.

Alola, A. A. and Kirikkaleli, D. (2019). The nexus of environmental quality with renewable consumption, immigration, and healthcare in the US: wavelet and gradual-shift causality approaches. Environ. Sci. Pollut. Res. 26(34), 35208-35217.

Alola, A. A., Yalçiner, K., Alola, U. V. and Saint Akadiri, S. (2019). The role of renewable energy, immigration and real income in environmental sustainability target. Evidence from Europe largest states. Sci. Total. Environ. 674, 307-315.

Alola, A. A. (2019a). The trilemma of trade, monetary and immigration policies in the United States: accounting for environmental sustainability. Sci. Total. Environ. 658, 260-267.

Alola, A. A. (2019b). Carbon emissions and the trilemma of trade policy, migration policy and health care in the US. Carbon Management, 10(2), 209-218.

Aloui R, Gupta R, Miller S (2016) Uncertainty and crude oil returns. Eng. Econ. 55:92–100

Altig, D., Baker, S.R., Barrero, J.M., Bloom, N., Bunn, P., Chen, S., Mizen, P., et al. (2020). Economic Uncertainty before and During the COVID-19 Pandemic. (No. w27418), National Bureau of Economic Research.

Antonakakis N., Chatziantoniou I. and Filis G. (2014) Dynamic spillovers of oil price shocks and economic policy uncertainty. Eng. Econ. 44: 433–447

Apergis, N. and Ozturk, I. (2015). Testing environmental Kuznets curve hypothesis in Asian countries. Ecolog. Ind. 52, 16-22.

Appiah M. (2018) Investigating the multivariate Granger causality between energy consumption, economic growth and CO2 emissions in Ghana. Energy Policy, 112:198–208

Arbatli E., Davis S., Ito A. and Miake N. (2019) Policy Uncertainty in Japan. IMF

Arbatli, E. C., Davis, S. J., Ito, A. and Miake, N. (2017). Policy uncertainty in Japan (No. w23411). National Bureau of Economic Research.

Aslan A., Destek M. and Okumus İ. (2018) Bootstrap rolling window estimation approach to analysis of the Environment Kuznets Curve hypothesis: evidence from the USA. Environ. Sci. Pollut. Res. 25(3): 2402–2408

Bachmann, R., Elstner, S. and Sims, E. R. (2013). Uncertainty and economic activity: Evidence from business survey data. Ame. Econ. J.: Macroeconomics, 5(2), 217-49.

Baek, J. (2015). A panel cointegration analysis of CO2 emissions, nuclear energy and income in major nuclear generating countries. Appl. Eng. 145, 133-138.

Bakas, D. and Triantafyllou, A. (2020). Commodity price volatility and the economic uncertainty of pandemics. Econ. Lett. 193, 109283.

Baker, S. R., Bloom, N. and Davis, S. J. (2016). Measuring economic policy uncertainty. The Qrt. J. Econ. 131(4), 1593-1636.

Baker, S.R., Bloom, N., Davis, S.J. and Terry, S.J. (2020). Covid-Induced Economic Uncertainty (No. w26983), National Bureau of Economic Research.

Balcilar M., Bekiros S. and Gupta R. (2017) The role of news-based uncertainty indices in predicting oil markets: a hybrid nonparametric quantile causality method. Empr. Econ. 53(3):879–889

Bekun, F. V., Agboola, M. O. and Joshua, U. (2020) Fresh insight into the EKC hypothesis in Nigeria: accounting for total natural resources rent. In econometrics of green energy handbook. Springer, Cham, p 221–243

Bernanke, B. S. (1983). Irreversibility, uncertainty, and cyclical investment. The Qtr. J. Econ. 98(1), 85-106.

Bloom N (2009) The impact of uncertainty shocks. Econometrica, 77(3): 623–685

Bloom, N. (2017). Observations on uncertainty. Australian Econ. Rev. 50(1), 79-84.

BP (2021). Statistical Review of World Energy. Available: https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html (Accessed: 01-04-2021)

Charles, A., Darné O. and Tripier, F. (2018) Uncertainty and the macroeconomy: evidence from an uncertainty composite indicator. Appl. Econ. 50(10):1093–1107

Chen, Z., Kahn, M. E., Liu, Y. and Wang, Z. (2018) The consequences of spatially differentiated water pollution regulation in China. J. Environ. Econ. Mgt, 88:468–485

Climate Transparency (2020). Brown to Green: The G20 Transition towards a Net-Zero Emission Economy. Available: https://www.climate-transparency.org/wp-content/uploads/2019/11/B2G_2019_Japan.pdf (Accessed: 02-04-2021)

Degiannakis, S., Filis, G. and Panagiotakopoulou, S. (2018). Oil price shocks and uncertainty: How stable is their relationship over time?. Economic Modelling, 72, 42-53.

Dogan, E. and Ozturk, İ. (2017) The influence of renewable and non-renewable energy consumption and real income on CO2 emissions in the USA: evidence from structural break tests. Environ. Sci. Pollut. Res. 24(11): 10,846–10,854

Dogan, E. and Turkekul, B. (2016) CO2 emissions, real output, energy consumption, trade, urbanization and financial development: testing the EKC hypothesis for the USA. Environ. Sci. Pollut. Res. 23(2):1203–1213

EIA, U (2021) Energy information administration. International Energy Outlook. US Department of Energy. https://www.eia.gov/international/overview/country/IDN. (retrieved 04 April 2021

Feng, L., Li, Z. and Swenson, D. L. (2017) Trade policy uncertainty and exports: evidence from China's WTO accession. J. Intl. Econ. 106:20–36

Fodha, M and Zaghdoud, O. (2010) Economic growth and pollutant emissions in Tunisia: an empirical analysis of the environmental Kuznets curve. Energ. Pol. 38(2):1150–1156

Grossman, G. M. and Krueger, A. B. (1995). Economic growth and the environment. The Qrt. J. Econ. 110(2), 353-377.

Grossman, G. M. and Krueger, A. B. (1991). Environmental Impacts of a North American Free Trade Agreement; National Bureau of Economic Research (NBER)Working Paper; No. 3914; NBER: Cambridge, MA, USA.

Gulen, H. and Ion, M. (2016). Policy uncertainty and corporate investment. The Rev. Fin. Stud. 29(3), 523-564.

Hailemariam, A., Smyth, R. and Zhang, X. (2019) Oil prices and economic policy uncertainty: evidence from a nonparametric panel data model. Energ. Econ. 83:40–51

Halicioglu, F. (2009) An econometric study of CO2 emissions, energy consumption, income and foreign trade in Turkey. Energ. Pol. 37(3):1156–1164

Hamilton, J. D. (1983). Oil and the macroeconomy since World War II. J. Political Econ. 91(2), 228-248.

Handley, K. and Limao, N. (2015). Trade and investment under policy uncertainty: theory and firm evidence. A. Econ. J.: Econ. Pol. 7(4), 189-222.

Hassett, K. A. and Metcalf, G. E. (1999). Investment with uncertain tax policy: Does random tax policy discourage investment. The Economic Journal, 109(457), 372-393.

Hu, S. and Gong, D. (2019). Economic policy uncertainty, prudential regulation and bank lending. Fin. Res. Lett. 29, 373-378.

Jiang, Y., Meng, J. and Nie, H. (2018) Visiting the economic policy uncertainty shocks-economic growth relationship: Wavelet-based Granger-causality in quantiles approach. Romania J. Econ. Forecast, 21(2):80–94

Jiang, Y., Zhou, Z. and Liu, C. (2019). Does economic policy uncertainty matter for carbon emission? Evidence from US sector level data. Environ. Sci. Pollut. Res. 24380-24394.

Julio, B. and Yook, Y. (2016) Policy uncertainty, irreversibility, and crossborder flows of capital. J. Intl. Econ. 103:13–26

Koc, S. and Bulus, G. C. (2020) Testing validity of the EKC hypothesis in South Korea: role of renewable energy and trade openness. Environ. Sci. Pollut. Res. 27: 29043–29054

Kuznets, S. (1955). Economic growth and income inequality. The Ame. Econ. Rev. 45(1), 1-28.

Leal, P. H. and Marques, A. C. (2020). Rediscovering the EKC hypothesis for the 20 highest CO2 emitters among OECD countries by level of globalization. Intl. Econ. 164, 36-47.

Lee, J. and Strazicich, M. C. (2003). Minimum Lagrange multiplier unit root test with two structural breaks. Rev. Econ. Stat. 85(4), 1082-1089.

Mardani, A., Streimikiene, D., Cavallaro, F., Loganathan, N. and Khoshnoudi, M. (2019). Carbon dioxide (CO2) emissions and economic growth: A systematic review of two decades of research from 1995 to 2017. Sci. Total Environ. 649, 31-49.

Menyah K. and Wolde-Rufael, Y. (2010) Energy consumption, pollutant emissions and economic growth in South Africa. Eng. Econ. 32(6): 1374–1382

Narayan, P. K., Saboori, B. and Soleymani, A. (2016). Economic growth and carbon emissions. Econ. Modelling, 53, 388-397.

Odugbesan, J. A. and Rjoub, H. (2019). The Causal Relationship Between Economic Growth and Remittance in Mint Countries: An ARDL Bounds Testing Approach to Cointegration. J. Acad. Res. Econ. 11(2), 310-329

Odugbesan, J. A. and Rjoub, H. (2020a). Relationship among economic growth, energy consumption, CO2 emission, and urbanization: evidence from MINT countries. Sage Open, 10(2), 2158244020914648.

Odugbesan, J. A. and Rjoub, H. (2020b). Evaluating HIV/Aids prevalence and sustainable development in sub-Saharan Africa: the role of health expenditure. Afr. Health Sci. 20(2), 568-578.

Odugbesan, J. A., Ike, G., Olowu, G. and Adeleye, B. N. (2020). Investigating the causality between financial inclusion, financial development and sustainable development in Sub-Saharan Africa economies: The mediating role of foreign direct investment. J. Pub.Affairs, e2569.

Olanipekun, I., Olasehinde-Williams, G. and Akadiri, S. (2019). Gasoline prices and economic policy uncertainty: what causes what, and why does it matter: evidence from 18 selected countries. Environ. Sci. Pollut. Res. 26(15):15,187–15,193

Ozatac, N., Gokmenoglu, K. K and Taspinar, N. (2017). Testing the EKC hypothesis by considering trade openness, urbanization, and financial development: the case of Turkey. Environ. Sci. Pollut. Res. 24(20): 16690–16701

Park, Joon Y. (1992). "Canonical Cointegrating Regressions," Econometrica, 60, 119-143.

Pata, U. K and Aydin, M. (2020). Testing the EKC hypothesis for the top six hydropower energy-consuming countries: evidence from Fourier bootstrap ARDL procedure. J. Clean. Prod. 121699

Peng, H., Tan, X., Li, Y. and Hu, L. (2016). Economic growth, foreign direct investment and CO2 emissions in China: a panel granger causality analysis. Sustainability, 8(3), 233.

Pesaran, M. H., Shin, Y. and Smith, R. J. (2001). Bounds testing approaches to the analysis of level relationships. J. Appl. Econ. 16(3), 289-326.

Phillips, P. C. and Hansen, B. E. (1990). Statistical inference in instrumental variables regression with I (1) processes. The Rev. Econ. Stud. 57(1), 99-125.

Pirgaip, B. and Dinçergök, B. (2020). Economic policy uncertainty, energy consumption and carbon emissions in G7 countries: evidence from a panel Granger causality analysis. Environ. Sci. Pollut. Res. 27, 30050-30066.

Richmond, A. K. and Kaufmann, R. K. (2006). Is there a turning point in the relationship between income and energy use and/or carbon emissions?. Ecolog. Econ. 56(2), 176-189.

Rjoub, H., Odugbesan, J. A., Adebayo, T. S. and Wong, W. K. (2021). Investigating the Causal Relationships among Carbon Emissions, Economic Growth, and Life Expectancy in Turkey: Evidence from Time and Frequency Domain Causality Techniques. Sustainability, 13(5), 2924.

Romano, T. and Fumagalli, E. (2018). Greening the power generation sector: Understanding the role of uncertainty. Ren. Sustain. Energ. Rev. 91, 272-286.

Saboori, B., Sulaiman, J. and Mohamed, S. (2012) Economic growth and CO2 emissions in Malaysia: a cointegration analysis of the environmental Kuznets curve. Energ. Pol. 51:184–191

Saidi, K. and Mbarek, M. B. (2017). The impact of income, trade, urbanization, and financial development on CO 2 emissions in 19 emerging economies. Environ. Sci. Pollut. Res. 24(14):12748–12757

Salahuddin, M., Gow, J. and Ozturk, I. (2015). Is the long-run relationship between economic growth, electricity consumption, carbon dioxide emissions and financial development in Gulf Cooperation Council Countries robust?. Ren. Sustain. Energ. Rev. 51, 317-326.

Shahbaz, M., Solarin, S. A., Hammoudeh, S. and Shahzad, S. J. (2017). Bounds testing approach to analyzing the environment Kuznets curve hypothesis with structural beaks: the role of biomass energy consumption in the United States. Eng. Econ. 68:548–565

Shahbaz, M. and Sinha, A. (2019). Environmental Kuznets curve for CO2 emissions: a literature survey. J. Econ. Stud. MPRA Paper No. 86281. Available: https://mpra.ub.uni-muenchen.de/86281/

Shahbaz, M. Gozgor, G., Adom, P. K. and Hammoudeh, S. (2019). The technical decomposition of carbon emissions and the concerns about FDI and trade openness effects in the United States. Intl. Econ. 159, 56-73.

Shahbaz, M., Hye, Q. M. A., Tiwari, A. K. and Leitão, N. C. (2013). Economic growth, energy consumption, financial development, international trade and CO2 emissions in Indonesia. Ren. Sustain. Energ. Rev. 25, 109-121.

Soytas U. and Sari, R. (2003). Energy consumption and GDP: causality relationship in G7 countries and emerging markets. Eng. Econ. 25:33–37

Stern, D. I. (2017). The environmental Kuznets curve after 25 years. J. Bioeconomics, 19(1), 7-28.

Usman, O., Alola, A. A. and Sarkodie, S. A. (2020). Assessment of the role of renewable energy consumption and trade policy on environmental degradation using innovation accounting: Evidence from the US. Ren. Energ. 150, 266-277.

Wang, Q., Jiang, X. T., Ge, S. and Jiang, R. (2019). Is economic growth compatible with a reduction in CO2 emissions? Empirical analysis of the United States. Res. Conserv. Recyc. 151, 104443.

Wang, Q., Xiao, K. and Lu, Z. (2020). Does Economic Policy Uncertainty Affect CO2 Emissions? Empirical Evidence from the United States. Sustainability, 12(21), 9108.

Wang, Y. and Shen, N. (2016). Environmental regulation and environmental productivity: The case of China. Ren. Sustain. Energ. Rev. 62, 758-766.

World Bank (2021) World development indicators. http://data.worldbank.org/(retrieved 5 Apr 2021)

World Bank (2021). World Development Indicators. The World Bank, Washington, DC, U.S.A

Zhao, X. and Sun, B. (2016) The influence of Chinese environmental regulation on corporation innovation and competitiveness. J. Clean. Prod. 112: 1528–1536

Zivot, E. and Andrews, D. W. K. (2002). Further evidence on the great crash, the oil-price shock, and the unit-root hypothesis. Journal of business & economic statistics,20(1), 25-44.