

The Role of Renewable Energy, Immigration and Real Income in Environmental Sustainability Target. Evidence from Europe Largest States

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Abstract

In spite of the continued deployment of technologies, innovations toward addressing the challenges of global warming, forecasting and sustaining quality environment have remained the herculean endeavour of the advanced states. Also, being migrants' destinations, resulting from the availability of economic opportunities, the target of attaining low-carbon, energy efficiency, and the cleaner atmospheric environment by these advanced economies are further bewildered. In that light, we investigate the impact of renewable energy consumption and migration on the

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carbon dioxide emissions of the panel of EU's largest economies of France, Germany, and the United Kingdom over the period of 1990 – 2016. The consistency of the Group FMOLS and DOLS presents elasticity of -0.13 and -0.14 respectively for the nexus of renewables and CO₂. Similarly, 0.04 and 0.05 are the respective elasticity of the two models for the nexus of migration and CO₂. In support of extant literature, the nexus of CO₂ with GDP and CPI are significant, and respectively positive and negative. In addition, the study reveals evidence of Granger causality with feedback between renewable energy consumption and CO₂, and between CPI and CO₂. On the other hand, a unidirectional Granger causality running from migration to CO₂ is observed. In practical term, the study presents policy frameworks for the examined countries and other advanced nations. The implementation of the presented policy pathways are potentially geared toward a forecastable, sustainable environmental quality and energy efficiency targets.

Keyword: Environmental quality; Carbon emissions; renewable energy consumption; migration; France, Germany, United Kingdom.

1. Introduction

In recent years, energy technologies, innovations are some of the ploy that are directly targeted at reducing carbon dioxide emissions or in general the greenhouse gas. Across the globe, there have been relentless efforts toward mitigating the adverse effect of global warming, climate change, desertification, land degradation, and related human-environmental and ecological distortions. Carbon emissions have persistently become the world's most threatening issue facing the natural ecosystem and human development. This is the reason population-environment system (PES) which is mainly constituted by the dynamics of fertility, mortality, migration, and other social and economic factors cannot be exonerated from global challenge facing the ecosystem (Han et al., 2018). In spite of the efforts toward addressing this global challenge, the Intergovernmental

Panel on Climate Change (IPCC, 2014) reported that carbon emission has undesirably increased from 9434.4 million tons in 1961 to 34649.4 million tons in 2011. The CO₂ emission (most common greenhouse gas, GHG) primarily constitutes about 81% of the GHG, thereby responsible for the global climate change. In the report of the British Petroleum (BP) Statistical Review of World Energy (BP, June 2018), it mentioned that carbon dioxide emissions increased from 29714.2 million tons in 2009 to 33444.0 million tons in 2017. In spite of the Paris Agreement of 2015² and the strong drive toward reducing carbon emission by countries, the aforesaid report indicates that the global carbon dioxide emissions increased by 1.3% between 2006 and 2016, and also increased to 1.6% in the previous year (2017). Also, in the period 2007-2017, the growth rate of carbon dioxide emissions in the European region is about 2.5% and was reportedly the second highest globally.

In recent time, most developed countries have continued to experience significant declining growth rate in the volume of carbon dioxide emitted. For instance, 4152.2 million tons (third highest volume) of carbon dioxide is emitted by the European countries in the period 2007 to 2017 (BP, June 2018). As constituents of the aforesaid volume of emitted CO₂, the volume of the emission is higher in the order of Germany (763.8 million tons), United Kingdom (398.2 million tons), Italy (344 tons), and France (320.3 tons). Surprisingly, Germany with the highest volume of CO₂ is observed to have a growth rate of 0.1% in the same period 2007 to 2017. While the growth rate of CO₂ emission in France is highest (2.0%) among the countries, the United Kingdom record the lowest growth rate of -2.7% in the same period. Generally, human activities and other unavoidable factors have significantly contributed to the increasing volume of carbon dioxide in most advanced countries through the disruption of the carbon cycle.

² More details relating to the Paris Agreement of 2015 is contained is available at: <https://unfccc.int/process/conferences/pastconferences/paris-climate-change-conference-november-2015/paris-agreement>.

In turning down the heat i.e cutting down carbon emissions in these countries and in other large economies of the world, countries have intensified the development of efficient energy source. For instance, three of the aforementioned countries; France, Germany, and the United Kingdom have shown a considerable increase in the development of renewable energy. In 2017, Germany invested about \$10.4 billion in renewable energy (the highest in Europe), followed by the United Kingdom with \$7.6 billion, thirdly by Sweden with \$ 3.7 billion, and France with \$2.6 billion (United Nations Environment Program, UNEP, 2018). Resulting from this investment, thousands of Megawatts of renewable energy sources was generated to produce electricity during the previous year 2017. For instance, the renewable power capacity which represents the maximum net generating capacity of power plants and other renewable energy installations for Germany, France, and the United Kingdom respectively produced 113, 058 Megawatts, 46, 678 Megawatts, and 40, 789 Megawatts electricity in 2017 (International Renewable Energy Agency IRENA, 2018).

Another dimension to this since the Second World War is migration (the movement of people from one location to the other with a motive of permanently or temporarily residing in the new location) and has continued to be a challenge across the globe. Generally, these movement of people is largely attributed to high and increasing population pressure on the scarce resources (Alola, 2019; Ma, & Hofmann, 2018; Alola & Alola 2018a). In Europe, the relocations of people (legally or illegally) that includes asylum seekers, refugees and migrants was peaked in 2015 to 2016 in Europe at yet the highest level since spillover effect of the Second World War. The concern associated with the record experience during the time period mentioned earlier is not unconnected with the irregular immigration of people from outside the European Union (EU) bloc. Although these migrants that are largely from the Middle East and Africa face the hurdle of

en route the frontline Southern countries (Italy, Greece, Malta, e.t.c. are frontlines countries), and the hardline Central and Eastern European states (Poland and Hungary are examples), their major target countries are the more prosperous Northern European countries (these include France, Germany, and the United Kingdom). Importantly, since 2015 Germany who has received the highest number of asylum seekers and other migrants have recently considered a retrospect of its approach likewise France and the United Kingdom. The multiplicity of problems; socioeconomic, environmental, and among other challenges associated with this movement of people have triggered discuss on wider border control and migration policy across the EU.

On this note, the current study is designed to underpin the trilemma of the simultaneous frameworks of the development of renewables, migration policy and real income considering the growing trend of energy demand and decarbonization agenda of the advanced economies. The study hypothesize the impacts of renewable energy consumption, migration policies, and the real income on the environment quality vis-à-vis carbon emissions of France, Germany, and the United Kingdom. The approaches of Fully-Modified Ordinary Least Square (FMOLS) and the Dynamic Ordinary Least (DOLS) are engaged in the investigation over the time period 1990 – 2016. Although previous studies employed the panel studies of categorization of the EU countries using varieties of methodologies (Karmellos, Kopidou & Diakoulaki, 2016; Moutinho, Madaleno & Silva, 2016; Soytaş & Sari, 2009), the specifics of the novelty of the current study seeks to close notable gap in extant literature accordingly:

- The examined panel countries that include France, Germany, and the United Kingdom have rarely been investigated in a panel study at least within the current context. Being the largest three economies of the European Union countries, the specificity of their

economic characterization in relation to approaches toward attaining efficient energy and meeting their respective low carbon targets makes this an informative study.

- Also, the reason for switching from high-carbon energy to alternative energy like the renewables is mainly to cut back the effects of global warming associated with the greenhouse gases. The desire to meeting the above objective by France, Germany, and the United Kingdom have over time contended with yet another inhibiting factor, the potential challenges posed by forms of migration. Hence, investigating the response of the carbon emissions level to the intrigues associated with the development of renewable energy, immigration policy, and real income dynamics in the panel countries is posed to divulge interesting and uncommon empirical interpretation. The aforementioned potential environmental quality determinants are akin to the innovation polices employed in the study of Fernández-Sastre & Montalvo-Quizhpi (2019).
- Lastly, by employing the Granger causality of Dumitrescu and Hurlin (2012) to underpin the interaction between the observed factors, it study tends to reflect a unique underpinning of historical information and adds to the body of existing literature.

The rest of the sections are in part. The next section (2) contains a synopsis of the previous studies. The materials and methodologies employed are presented in section 3 while the results are discussed in section 4. Section 5 offers concluding remarks that include policy implication of the study and proposal for future study.

2. Background: A synopsis

In tackling the global challenge of climate change, the European Union has reaffirmed its position and commitment toward attaining a sustainable environment. The focus is to reduce carbon emissions which majorly constitutes the component of the GHG and a primary causative

of climate change. Although the EU have over-achieved its earlier CO₂ and greenhouse gas reduction commitment within the first period of the Kyoto Protocol (2008-2012), further targets were being set to compliments ongoing researches on the subject. In the literature and in recent time, the emission of carbon dioxide in the developed countries (like the France, Germany, UK, US, and even China) has continued to be associated with varieties of factors (Akadiri, S. S., Alola, A. A & Akadiri, A. C., & Alola, U. V. (Forthcoming); Ahmadalipour et al., 2019; Ma & Hofmann, 2018; Atinkpahoun et al., 2018; Alola & Alola, 2018b; Aunan & Wang, 2014).

In a recent study, Bekun, Alola and Sarkodie, 2019 examined the nexus renewables, non-renewable energy, natural resource rent, and environmental sustainability for sixteen selected EU countries. Bekun, Alola and Sarkodie (2019) employed the Pooled Mean Group (PMG) approach with an Autoregressive Distributed Lag (ARDL) for the period 1996-2014 and found that renewable energy consumption in the panel countries favours the environmental sustainability goals and energy policies of the examined countries. Interestingly, it suggests that these countries are on right pathway mechanism toward achieving the Sustainable Development Goals (SDGs) 2030 especially through their energy diversification policies. On the other hand, the study posits a long-run negative impact of both economic growth (an indicator for growth in real income) and natural resource rent on environmental sustainability. This implies that the economies of the panel of EU-16 countries (among are France, Germany, and UK) are expected to grow at the expense of their environmental quality. Although both economic growth and the natural resource rent are observed to negatively impact the quality of the environment in these countries, the impact of the consumption of the fossil fuel is observably more damaging. On a general note, the aforementioned results has little or no deviation from the study of Karmellos, Kopidou and Diakoulaki (2016) for the EU-28 and other related studies (Shuai, Chen, Wu, Zhang & Tan,

2019; Dong, Jiang, Sun & Dong, 2018; Nguyen & Kakinaka, 2018; Duman & Kasman, 2018; Kasman & Duman, 2015; Lu, Lin & Lewis, 2007).

Specifically, Karmellos, Kopidou and Diakoulaki (2016) investigated the EU-28 by adopting the Log Mean Divisia Index (LMDI) method for the decomposition analysis of CO₂ emissions from electricity generation of the EU-28 countries during the period 2000 – 2012. The LMDI method employed in the study provides decomposition without residual terms and is consistent in aggregation as such that is capable of computing zeros and negative values. In the study, the driving factors of CO₂ across EU-28 reflects the major policy frameworks underlying the EU approach to sustainable development. These factors include the activity effect (economic performance indicator), the electricity intensity effect (ratio of total electricity consumption to total GDP), the electricity trade effect (ratio of electricity production to electricity consumption), and the energy efficiency effect (ratio of fuel input to the respective electricity output). Among the factors enumerated above, the activity effect is observed as the main factor contributing to the change in CO₂ emissions in all the estimated panel countries. Carbon dioxide emissions were also observed to increase by 12% during the period 2000 - 2007 in 22 of the 28 estimated countries.

Furthermore, similar to the study of trade-monetary-immigration nexus and the environmental sustainability of the US by Alola (2019), Han et al (2018) examined the dynamics of migration and particulate (PM_{2.5}) in China. The concern of particulate pollution resulting from population change which is strongly induced by rapid urbanization in China has propelled the study of Han et al (2018). Han et al (2018) identified the important role of migration in urbanization, thus examining the impact of the magnitude of population migration especially in the rapidly

developing Chinese regions. In the study, the PM_{2.5} was employed to proxy for environmental pollution and thus establishing a strong relationship between the observed variables. The study found that increased population density (especially in Eastern China, Western China, and the country's high population density regions) implies increase in the PM_{2.5} over the period 2000-2014. The implication of the study of Han et al (2018) is a needful call on countries to design urbanization strategic plan especially that address the forms of migration in order to mitigate the risks of environmental degradation. In the study of the immigration/migration-environmental sustainability nexus, the observation from Han et al (2018) and Rafiq, Nielsen and Smyth (2017) slightly differs from that of Ma and Hofmann (2018) and Aunan and Wang (2014). In specific, Ma and Hofmann (2018) observed a weak link between immigration and environmental quality. Rather, the study posits that native population causes more environmental pollution than the immigrant population in the US. But the study hinted that the tendency of immigrants in improving the air quality would largely depend on the country of origin of the immigrants. While Aunan and Wang (2014) noted that rural-urban migration across most Chinese provinces have significantly reduced the population exposure to PM_{2.5} especially because of the expected change in the peoples' lifestyles, Rafiq, Nielsen and Smyth (2017) noted otherwise for inter-provincial migration and for SO₂ pollutions in China.

Moreover, handful of European countries-specific and related studies have also been conducted in recent time (Cooper, Stamford & Azapagic, 2018; Cansino, Román & Ordonez, 2016; Robaina-Alves, Moutinho & Costa, 2016; Baiocchi, Minx & Hubacek, 2010). Specifically for the United Kingdom, Cooper, Stamford and Azapagic (2018) recently observed that the development of shale gas in the UK especially for the future energy scenario (toward 2030) is less perceived to be environmental friendly compared to wind, solar. Hence, the study suggests

that lower share of shale gas in the country's electricity mix of 2030 is more sustainable. Also for the UK, Baiocchi, Minx and Hubacek (2010) emphasized that carbon dioxide emissions in the country vary directly and indirectly with the consumer behaviour of different lifestyles of the consumers as well social factors associated with the people. On different notes, Cansino, Román and Ordonez (2016) and Robaina-Alves, Moutinho and Costa (2016) respectively investigated the drivers of carbon dioxide emissions in Spain and Portugal by both applying a decomposition analysis. While the former examined carbon dioxide emissions in a six-sectoral levels analysis, the later investigated the contribution of Portuguese tourism sector to carbon dioxide emissions over a different period of time.

3. Materials and Methods

3.1 *Description of Materials*

A multivariate approach is adopted in this study by incorporating four explanatory variables of annual dataset spanning from 1990 to 2016. The two main independent variables deployed are:

- The renewable (*ren*, is the final renewable energy consumption measure in Million tons of energy, Mtoe) from the European Commission (EU, 2018) and
- The migration index (*mgr*, it is an indicator for the movement of people within a territory which proxy for the immigration policy). The migration indices are the policy categories³ which comprises the ranges of sub-indexes from news data. Information from the employed news categories is derived from the Access World News database of thousand newspapers which were categorically normalized into series and made available online (http://www.policyuncertainty.com/categorical_epu.html).

³ More details on the US Policy categorical indices are available at http://www.policyuncertainty.com/categorical_epu.html.

Other independent variables of interest are the consumer price index (*cpi*) from the World Development Indicator of the World Bank database (WDI, 2018) and the Gross Domestic Product (*GDP* is the Mrd, billion Euro at current price) from the European Commission (EU, 2018). These variables, *CPI* and *GDP* are appropriately employed in this study to account for other unobserved factors to avoiding possible biases caused by an omitted variable. Specifically, the selection of the *GDP* gives a trend of the economic growth of the countries while the *CPI* captures the effects associated with consumer items that include energy technologies.

Also, the European Commission (EU, 2018) is the source of the dependent variables employed i.e. the total Carbon dioxide (*CO₂*) emissions and the Greenhouse gas (*GHG*) which are equivalent of Million Tons of Carbon Dioxide including international aviation. The descriptive statistics are implied in Table 1.

<Insert Table 1 here>

3.2 Methodology: theoretical concept

Several guidelines for estimating direct CO₂ emissions have been applied in extant literature over time (Al-Mulali, Tang & Ozturk, 2015; Farhani & Ozturk, 2015; Wang & Zhao, 2018 Yu, Deng & Chen, 2018). Here, our study incorporates migration index (*mgr*) in lieu of health expenditure in addition to renewable energy consumption (*ren*) in the recent work of Apergis, Jebli & Youssef (2018) and allows Gross Domestic Product (*GDP*) and consumer price index control for unobserved factors. Hence, the panel empirical expression under investigation is given as:

$$Co_{2\ i,t} = f(gdpi_{i,t}, cpi_{i,t}, ren_{i,t}, migration_{i,t}) \quad (1)$$

Then, the natural logarithmic transformation of the above expression (equation 1) is given by:

$$l Co_{2\ i,t} = \alpha + \beta_1 l gdpi_{i,t} + \beta_2 l cpi_{i,t} + \beta_3 l ren_{i,t} + \beta_4 l migration_{i,t} + \epsilon_{i,t} \quad (2)$$

for all $t = 1990, \dots, 2016$, $i = 1, 2$, and 3 (respectively for France, Germany and the United Kingdom). And, β_s are the degree of response of the logarithms of the explanatory variables to the logarithms of CO_2 given that ε is iid $\sim N(\mu, \sigma^2)$ for every i and t .

3.2.1 The panel unit root tests

In the meantime, we engage the panel unit root test by Im, Pesaran and Shin (IPS, 2003) because of advantage in modelling both cross-sections and balanced panel data that possesses identically distributed variance and mean of error terms (as in the case of the investigated countries, *France*, *Germany*, and the *United Kingdom*). Generally, the method uses the evidence on unit root hypothesis from N unit root tests to examine through DF or ADF regression⁴ based on the N cross-section units of the aforementioned variables y as expressed below:

$$y_{i,t} = \alpha_i + \rho_i y_{i,t-1} + \varepsilon_{i,t}$$

where $t = 1, 2, \dots, T$, null hypothesis (H_0) against the alternatives (H_1) are respectively given as:

$$H_0 = \rho_i = 1, \forall i = 1, 2, \dots, N$$

$$H_1 = \rho_i < 1, \forall i = 1, 2, \dots, N_1; \rho_i = 1, \forall i = N_1 + 1, N_1 + 2, \dots, N$$

Similarly, both the Levin, Lin & Chu, (LLC, 2002)⁵ and the Fisher-Augmented Dickey-Fuller/Phillips-Perron panel unit root method, as modified by Maddala and Wu (1999) and Choi (2001) from Fisher's (1932) are additionally employed. The step-by-step procedure is skipped here due to page constraint.

The panel unit root test results from the three aforesaid methodologies are presented in Table 2.

<Insert Table 2>

3.2.2 The cointegration estimation

⁴ Because of space constraint, the detail and step by step procedure of panel unit root test by IPS and Fisher-ADF/PP are respectively provided by Im, Pesaran and Shin (2003) and Maddala and Wu (1999)

⁵ Also, details on LLC is contained in Levin, Lin and Chu (2002)

A pre-test to investigate panel cointegration evidence by Pedroni residual and Kao (1999) are essentially employed before using the FMOLS and DOLS estimators. The tests affirm strong evidence of cointegration in the panel as depicted in the upper part of Table 3.

In this investigation, the Fully-modified ordinary least square (FMOLS) and dynamic ordinary least square (DOLS) estimators are employed as to overcome the challenges of endogeneity in the series and the serial correlation issue from the error term. While the FMOLS (an asymptotically unbiased estimator) employs the semi-parametric correction approach to investigate the long-run relationship of Phillips and Hansen (1990), Saikkonen (1992) and Stock and Watson (1993) modelled with a more efficient asymptotic estimator. Given the idea of a fixed effect model, the equation 2 could be expressed as:

$$lco_{2i,t} = \alpha_i + \beta x_{i,t} + \varepsilon_{i,t} \quad (3)$$

given that for every $i = 1$ to 3 (i.e $i=1$ for France, $i=2$ for Germany, and $i = 3$ for the United Kingdom), $t = 1, 2, \dots, T$ for all series. α_i are intercepts for the cross sections, $\varepsilon_{i,t}$ are stationary disturbance terms. Also, given that $x_{i,t}$ are the vector of independent variables ($lgdp$, $lcpi$, $lren$, and $lmgr$) such that β is the vector of parameter for each $x_{i,t}$, the autoregressive form is

$$x_{i,t} = x_{i,t-1} + \varepsilon_{i,t} \quad (4)$$

Hence, the basis of the model will be to estimate the panel cointegrating vector β , this is obtained from

$$\hat{\beta}_{FMOLS} = \left\{ \sum_{i=1}^2 \sum_{t=1}^T (x_{i,t} - \bar{x}_i) (x_{i,t} - \bar{x}_i)' \right\}^{-1} * \left\{ \sum_{i=1}^2 \left(\sum_{t=1}^T (x_{i,t} - \bar{x}_i) (\overline{lhpi}_{i,t} - T \Delta \varepsilon u) \right) \right\} \quad (5)$$

but, augmenting the cointegrating regression using lag and lead difference of the independent variables ($lgdp$, $lcpi$, $lren$, and $lmgr$) with the DOLS approach, we then have

$$lco_{2i,t} = \alpha_i + \beta_i x_{i,t} + \sum_{k=-p_1}^{p_2} \lambda_k \Delta lco_{2i,t-k} + \sum_{k=-q_1}^{q_2} \gamma_k \Delta x_{i,t-k} + \mu_{i,t} \quad (6)$$

Also, in Table 3, the remaining information in the lower part contains the results of the above-mentioned estimations.

<Insert Table 3>

3.2.3 Dynamic Granger causality

Given the asymptotic distribution vis-à-vis the value of T (27) to be greater than N (3), the panel Granger causality approach by Dumitrescu and Hurlin (2012) for heterogeneous non-causality, is appropriately employed using the expression below:

$$Co_{2it} = \alpha_i + \sum_{r=1}^R \beta_i^{(r)} co_{2i,t-r} + \sum_{r=1}^R \gamma_i^{(r)} x_{i,t-r} + \varepsilon_{i,t} \quad (7)$$

The fixed effect denoted by α_i is neglected in this case as the equation implies a Granger causality from x to co_2 where $x = f(lgdp, lcpi, lren, \text{ and } lmgr)$ i.e each of the independent variable. Also, the above expression possess the potential of estimating in a two-directional manner for a pair of estimated variables with lag length R , It further shows that $\beta_i^{(r)}$ is the autoregressive parameter (coefficient of the lag of the dependent variable) while $\gamma_i^{(r)}$ is the regressor coefficients for each estimates. Because Granger causality test assumes a heterogeneously normal distribution, a homogenous non-stationary (HNC) employed for the hypothesis testing is illustrated as:

$$H_0 = \gamma_i = 0, \forall i = 1, 2, \dots, N$$

$$H_1 = \gamma_i = 0, \forall i = 1, 2, \dots, N_1; \gamma_i \neq 0, \forall i = N_1 + 1, N_1 + 2, \dots, N$$

given that $\gamma_i = (\gamma_i^1, \dots, \gamma_i^R)$, $N_1 = N$ indicates that causality of any member of the panel but $N_1 = 0$ indicates causality within cross-sections as the value N_1/N is reasonably less than one. The estimate of the Granger causality test is presented in Table 4.

<Insert Table 4>

3.3 Robustness and diagnostic tests

The robustness of the outline-above for appropriateness by re-modeling equation (1). By replacing the carbon dioxide emissions (CO_2) with the Greenhouse gas emissions (GHG) of the equation (1), a robustness check is performed by using,

$$lGHG_{i,t} = \alpha + \beta_1 l gdp_{i,t} + \beta_2 l cpi_{i,t} + \beta_3 l ren_{i,t} + \beta_4 l migration_{i,t} + \varepsilon_{i,t} \quad (8)$$

The check procedures include a replicated FMOLS and DOLS methods earlier described

Given the observation from the aforesaid re-estimation (also see Table 3), the result further support the suitability of the methodological concept adopted.

Furthermore, the residual tests of both serial correlation Langrange multiplier and heteroskedasticity tests found strong significant evidence of no serial correlation and very weak evidence of heteroskedasticity (see the upper part of Table 4 above)

<Insert Figure 1>

<Insert Figure 2>

4. Results and Discussion

During the time period 1990 – 2016, as depicted in the descriptive Table 1, the estimated statistics offers useful empirical inference. The results indicate that carbon dioxide emissions and the greenhouse gas in Germany and the United Kingdom are significantly more than the emissions obtainable in France. In the same vein, renewable energy was less consumed in Germany and the United Kingdom. For instance, while Germany recorded maximum CO_2 and GHG of 1064.957 and 1263.708 respectively against 439.8868 and 581.9684 for France, the CO_2 and GHG in the United Kingdom is peaked at 621.7030 and 821.058 against the aforementioned values for France during the period 1990 – 2018. Obviously, this observation is best accounted

for by the disparity in the volume of renewable energy consumed across these countries over the same period. In France, 8.347000 Mtoe was the minimum renewable energy consumed, while 2.670000 Mtoe and 0.398000 Mtoe of renewables were consumed in Germany and the United Kingdom respectively. Specifically, in Germany, the growth rate of renewable energy consumed in the observed period is significantly higher while the migration index (rate of potential migration) was also highest. And, this is obtainable in the current reality of both the alternate energy use the migration policy in Germany. By intuition and economic logic, the observed economic growth (an indication of more economic activities) in Germany and the United Kingdom during the investigated period largely accounts for the massive increase in the carbon dioxide and greenhouse gas emissions. Although the renewable energy of the two countries (Germany and UK) were lower than that of France at some point, the use of other energy source especially the fossil fuels would likely be the driver of these economies at such instance. The behaviors indicates a partial heterogeneity (see Table 2).

On the nature of the relationship between the variables in the model, statistical evidence shows that the null hypothesis of no cointegration is rejected by the Pedroni Residual and Kao residual Panel Cointegration methods. An additional test to support the evidence of cointegration (long run) relationship was employed and the result indicated in Table 3. Also, the long-run cointegration estimates from the Fully-modified ordinary least square (FMOLS) and dynamic ordinary least square (DOLS) are presented. In adopting the FMOLS and DOLS approaches, the Pooled, Pooled weighted, and the Grouped Mean of both estimators were employed. As observed in the long-run relationship estimates of the explanatory variables and the independent variables are more consistent with the Grouped mean estimates. Therefore, the elasticity of the carbon dioxide emissions with respect to the renewable energy consumption, migration, gross domestic

product, and the consumer price index are respectively -0.13, 0.04, 0.245, and -0.66 using the FMOLS. Similarly, DOLS indicates that the elasticity of carbon dioxide emissions with respect to the renewable energy consumption, migration, gross domestic product, and the consumer price index are respectively -0.14, 0.05, 0.23, and -0.42. In both cases, the elasticity coefficient of renewable energy consumption and the consumer price index across the countries are negatives and significant, that of migration and gross domestic product are positive and significant. This reveals that the consumption of more renewable energy in the panel countries results in declining emissions of carbon dioxide (-0.13), thus leading to a desirable and sustainable environment. This suffices that the energy transition policy of these countries especially that is geared toward SDGs 2030 is commendable. An opposite effect is observed for migration and the economic growth of the countries. The finding supports the extant literature which indicates that economic growth justifies the preliminary phase of more environmental pollution (hindrance to a sustainable environmental drive) at least before an eventual evidence of the Environmental Kuznets Curve (EKC) hypothesis (Farhani & Ozturk, 2015; Grossman & Krueger, 1995; Sówka & Bezyk, 2018). In the current study, the result of immigration-environmental sustainability nexus is slightly different from the one obtained by Ma and Hofmann (2018) for the case of US. While Ma and Hofmann (2018) suggests that the contribution of carbon emissions to the air quality of the host country (US) depends on the country of origin of the migrants, the current study posits that immigration causes more damage to the environment. But the account of migration and CO₂ emission nexus which is likened to urbanization and CO₂ nexus in the study of Al-mulali, Sab & Fereidouni (2012) is in tandem with the current study and Han et al (2018). Evidently, Al-mulali, Sab & Fereidouni (2012) observed that 84% of the examined countries accounts for evidence of long-run relationship between urbanization and carbon dioxide

emission. Also, as expected, the renewable energy consumption in the countries causes declining impact on the carbon dioxide emissions (improve the quality of air) in both FMOLS and the DOLS. This evidence supports the latest panel study of 42 sub-Saharan African countries by Apergis, Jebli and Youssef (2018) and that of Long, Naminse, Du and Zhuang (2015) for China during the period of 1952-2012.

Series of additional diagnostic and robustness test was conducted for the current study. Prior to the diagnostic test, the panel Granger causality by Dumitrescu and Hurlin (2012) as revealed in Table 4 shows that past historical information of renewable energy consumption is a good at explaining carbon dioxide emissions and with feedback. The same significant evidence is observed between the consumer price index and the carbon dioxide emissions, also with feedback. Expectedly, migration is observed to Granger cause the emissions of carbon dioxide but without feedback.

An interesting part of this study is the result of the robustness check. The robustness check is conducted by replacing the CO₂ in the model (equation 1) with the GHG. The result (see Table 3) presents a complete replica of the first model, such that the direction of impact of all the examined factors (variables) are the same. For instance, while renewable energy consumption and consumer price index are negatively related with the CO₂ emissions the impacts of GDP and migration on CO₂ emissions are positive. Also, the magnitude of the coefficient of estimations in the two cases (model with CO₂ and GHG) are of very small differential values.

The Wald test was observed to be significant in the two scenarios as indicated in the lower part of Table 3. Additionally, the residual diagnostic tests (see Table 4) show that there is no concern for serial correlation and heteroskedasticity. Both tests fail to reject the null hypotheses of 'no

serial correlation' and homoscedasticity at the statistical level of 1%. Lastly, the response of CO₂ emissions to Cholesky one standard deviation (in this case 1% shocks in the independent variables) is significant as indicated in Figures 1 and 2.

5. Concluding remarks

It is important to note that France, Germany, and the United Kingdom are uniquely related in few numbers of ways, that include the economies, energy trend, climatic composition, migration trend, and among others. As such, the present study investigated the dilemma associated with the effects of renewable energy consumption and migration trend on the carbon dioxide emissions in the panel countries over the period of 1990 to 2016. Sharing the mandate of an improved environmental degradation caused by greenhouse gas (such as CO₂), the countries have consistently reassured their commitment toward a sustainable and more efficient energy portfolio. Importantly, in our study, renewable energy consumption is observed to cause 0.13% and 0.14% decline in the emissions of carbon dioxide with FMOLS and DOLS respectively. Similarly, the study observed that migration causes 0.04% and 0.05% increase in the emissions of carbon dioxide in the panel countries with FMOLS and DOLS respectively. Desirably, the declining effect of renewable energy consumption on the carbon dioxide emissions is way higher than the counter impact of migration on the carbon dioxide emission. In spite of the aforesaid desirable observation, the panel countries would still have to strategically pursue the individual country policies on renewable energy and carbon dioxide emissions with keen and sustainable efforts.

In practical term, the EU member countries have an existing mandate on binding national targets to raise the shares of renewables in the energy consumption by 20% by the year 2020. Since consumption of renewables favours the decline in CO₂ emissions in the investigated countries, it

is expected that the countries further explore its renewable energy resources, like rivers suitable for hydroelectric power, effective utilization of sunshine for energy generation. Hence, the policy of the government should be geared toward encouraging the stakeholders, especially private investors and households to adopt more renewable energy portfolios. Because transportation and industrial sectors are known to account for the larger proportion of carbon dioxide emissions in the EU countries, the union's target of attaining 15% and 30% reduction in average emissions of continent's fleet of new cars by 2025 and 2030 respectively should be further prioritized. The investment policies of the government of the examined countries, especially which is tailored toward renewable energy should cover more sectors of the economy. For example, France which was originally observed to consume more renewables have been overtaken by Germany while the UK continues to struggle in the development of renewables mostly because of investment policies.

Except for Germany, the United Kingdom and France have in recent time exercise cold feet in their response toward easing migrants and refugees' movement. Since the study observed that a more tolerable migrant atmosphere in the countries will cause more environmental degradation (more CO₂ emissions), it suggests that the countries implement their migration policies painstakingly as to avoid disservice of their sustainable energy efficient and cleaner energy/economy strategies. In future time, other empirical approach that captures the destination and origin countries of the migrants could be studied in a comparative analysis.

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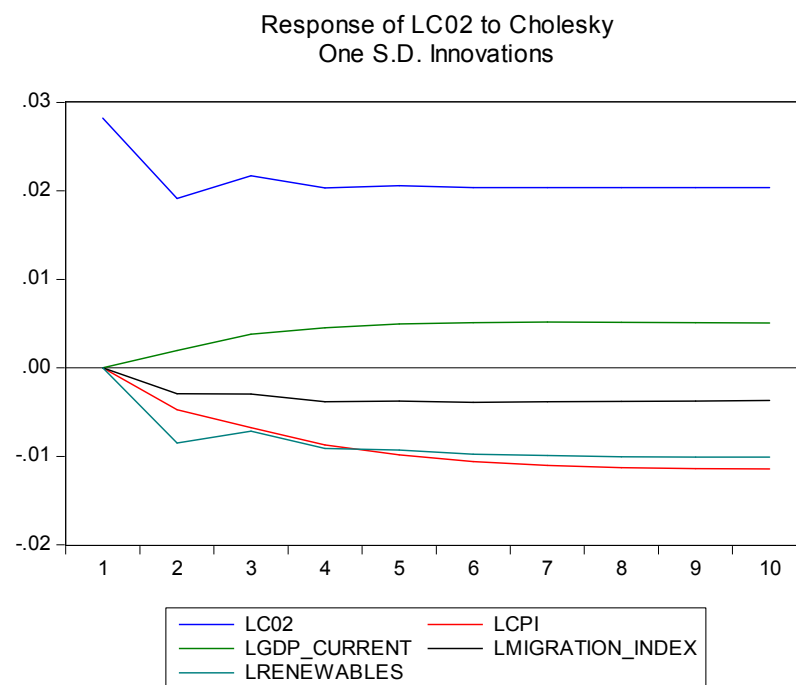


Figure 1: Response of lco_2 to the joint dynamics of the dependent variables

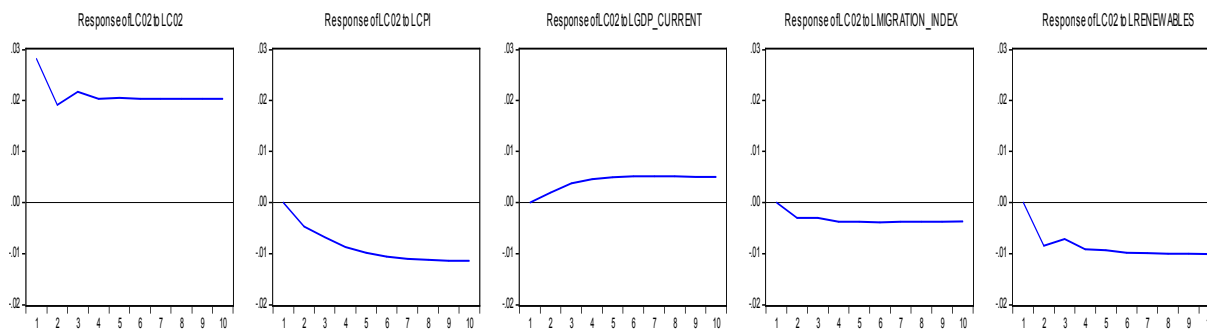


Figure 2: Response to Cholesky one S.D Innovations of the independent variable by lco_2 .

Table 1:		Descriptive statistics of the variables							
C	Var.	Mean	Median	Min.	Max.	S.D	Skewness	Kurtosis	Jarque-Bera
France									
	co ₂	409.1400	415.5556	350.2279	439.8866	26.50921	-0.873781	2.679274	3.551442
	ghg	542.9861	555.0549	470.6736	581.9684	33.98103	-0.965687	2.596895	4.379288
	cpi	89.94863	89.25285	71.18813	105.7726	11.06784	0.016828	1.705049	1.887784
	gdp	1640.844	1637.438	1004.342	2228.857	399.9351	-0.093218	1.604530	2.229857
	mgr	95.96600	94.26027	31.16654	210.6428	39.75226	0.929742	2.062754	3.887730
	ren	10.13922	9.821000	8.347000	12.36600	1.103988	0.382269	2.123725	1.521425
Germany									
	co ₂	909.4565	914.8755	814.3457	1064.957	64.69484	0.371279	2.673436	0.740292
	ghg	1052.392	1054.422	927.2303	1263.708	94.71261	0.391400	2.240141	1.338934
	cpi	90.24528	89.55746	67.47511	107.4173	11.63153	-0.147878	2.052276	1.108859
	gdp	2276.938	2220.080	1506.671	3144.050	448.4764	0.135985	2.263987	0.692643
	mgr	144.4388	114.6983	25.29562	359.9762	100.8772	0.803310	2.478664	3.209646
	ren	7.622778	6.968000	2.670000	14.27000	4.236774	0.184744	1.428424	2.932168
United Kingdom									
	co ₂	565.3703	589.2337	428.9248	621.7030	53.25304	-1.242670	3.327753	7.069877**
	ghg	706.3776	733.3776	516.8034	821.0381	87.07855	-0.738075	2.389528	2.870654
	cpi	87.76867	84.44838	62.43012	112.5419	14.77592	0.312958	2.023479	1.513532
	gdp	1701.563	1811.401	936.3691	2602.156	491.2612	-0.229664	1.945480	1.488370
	mgr	38.97542	6.351432	2.47347	105.9343	20.69683	1.6608.11	5.547176	19.71189*
	ren	1.437593	0.824000	0.398000	4.099000	1.209322	0.976303	2.394088	4.702278

Note: The series for both Cyprus and Malta are normally distributed. Min, Max, S.D implies Minimum, Maximum and Standard Deviation respectively. Co₂, ghg, cpi, gdp, mgr and ren are carbon dioxide emissions, greenhouse gas, consumer price index, real gross domestic product, migration index, and renewables respectively. Gdp is measured in Mrd (billion) Euro current prices, Co₂ and ghg are measured in Mio tons and ren is measured in Mtoe.

Table 2: Panel unit root test

Variable	LLC		IPS		Fisher-ADF	
	c	t	c	t	c	t
<i>lco₂</i>	1.54010	0.75426	2.46398	0.86744	2.90174	11.9541
<i>lghg</i>	1.83754	1.38625	3.36952	1.25171	1.87894	9.49365
<i>lcpi</i>	3.52490*	-0.61838	-1.81407**	-1.39468	19.2999*	14.4853**
<i>lgdp</i>	-2.92347*	1.00593	-0.19876	1.57542	6.73203	2.79701
<i>lmgr</i>	-4.71800*	-4.68887*	-4.24203*	-3.61192*	28.3948*	22.4048*
<i>lren</i>	0.42429	-0.68497	1.47471	0.13689	1.67396	4.00703
Δlco_2	-7.24323*	-7.64429*	-7.19336*	-8.66690*	51.0684*	56.6783*
$\Delta lghg$	-6.95013*	-5.95189*	-7.11179*	-8.06774*	50.7029*	54.1631*
$\Delta lcpi$	-2.54812*	-1.35995***	-2.34870*	-1.28495***	17.3581*	12.9447**
$\Delta lgdp$	-5.61754*	-5.52420*	-4.39977*	-2.01128*	29.0836*	24.8416*
$\Delta lmgr$	-8.09246*	-4.42464*	-9.57601*	-8.88245*	66.9015*	58.8114*
$\Delta lren$	-5.96247*	-3.55987*	-6.11748*	-4.26132*	41.5397*	26.9221*

Cross-sectional dependence test

Test	<i>lco₂</i>	<i>lghg</i>	<i>lcpi</i>	<i>lgdp</i>	<i>lmgr</i>	<i>lren</i>
Breusch-Pagan LM	49.94137*	60.92486*	79.36126*	71.97737*	8.4036828.94004*	
Breusch-Pagan LM	17.93899*	22.42298*	29.94961*	26.93515*	0.981297	9.365231*
Pesaran CD	6.976929	7.770899*	8.908475*	8.480003*	2.768594	4.973043

Note: * and ** are statistical significance at 1% and 5% respectively. Δ indicates first difference. Lag selection by SIC of maximum of 4 in all estimations. LLC, IPS and Fisher-ADF are the Levin, Lin and Chu (2002); Im, Pesaran and Shin (2003); Fisher-ADF by Maddala & Wu (1999) panel unit root tests. For the Cross-sectional dependence test, () is the p-value. C and t are the intercept and trend respectively and L implies the logarithmic transformation.

Table 3: Cointegration and long-run cointegration estimations

Pedroni Residual Panel Cointegration

Panel		Weighted panel		Grouped
V-statistic	1.5(0.06)	v-statistic	1.14(0.13)	rho-statistic -1.4(0.08)
Rho-statistic	-1.87(0.03)**	rho-statistic	-1.76(0.03)**	PP-statistic -5.0(0.00)*
PP-statistic	-4.53(0.00)*	PP-statistic	-4.41(0.00)*	rho-statistic -5.5(0.00)*
ADF-statistic	-4.18(0.00)*	ADF-statistic	-3.99(0.00)*	

Kao Residual cointegration

ADF {t-statistic} (p-value) {-5.126742} (0.0000)*

FMOLS and DOLS long-run cointegration estimates

<u>With ghg</u>	FMOLS			DOLS		
	G	P	P-W	G	P	P-W
<i>lcpi</i>	-0.58*	-0.41	-0.95*	-0.43	-0.28	-0.95*
<i>lgdp</i>	0.12	0.08	0.90*	0.13	-0.02	0.90*
<i>lmgr</i>	0.03*	0.03**	0.12**	0.06*	0.005	0.12**
<i>lren</i>	-0.12*	-0.06	0.31*	-0.14**	-0.08*	0.31*

With co₂

<i>lcpi</i>	-0.66**	-0.01	-1.30*	-0.42	-0.30	-0.35
<i>lgdp</i>	0.25**	0.10	1.34*	0.23	0.09	0.11
<i>lmgr</i>	0.04*	0.06**	0.07	0.05*	0.01	0.01
<i>lren</i>	-0.13*	-0.07	0.45*	-0.14**	-0.06**	-0.06

Wald Test, H_0 : Coefficients of *larr* and $lmgr = lren = 1$ (consider the Grouped estimations only)

*lco₂**lghg*

Grouped FMOLS: t-Stat = 10400*, χ^2 Stat = 20801* t-Stat = 13653*, χ^2 Stat = 27306*

Grouped DOLS: t-Stat = 2435*, χ^2 Stat = 4870* t-Stat = 2974*, χ^2 Stat = 5949*

Note: The lag selection by Schwarz Information Criteria (SIC) due to the number (small) of observations. FMOLS and DOLS are the Fully-modified ordinary least square and dynamic ordinary least square long-run estimation approaches. * and ** are respectively the 1% and 5% statistical significance level. Also, G, P and P-W are estimates for Group, Pooled and Pooled Weighted respectively.

Table 4: Diagnostic tests and Panel Granger causality

Residual Serial Correlation LM TestLM-stat = 23.81561 (*p-value* = 0.5300)Residual Heteroskedasticity TestChi-square = 212.2452 (*p-value* = 0.0503)Dumitrescu and Hurlin (2012) test

Null hypothesis	W-stat	P-value	Causality	Remark
$lco_2 \rightarrow lcpi$	14.68	0.0066	Yes	<i>Feedback</i>
$lncpi \rightarrow lco_2$	18.507	9.E-05	Yes	
$lmgr \rightarrow lco_2$	12.7067	0.0306	Yes	uni-directional
$lco_2 \rightarrow lmgr$	5.06185	0.7395	No	
$lren \rightarrow lco_2$	41.5369	0.0000	Yes	<i>Feedback</i>
$lco_2 \rightarrow lren$	21.9415	5.E-07	Yes	

Note: Co₂, ghg, cpi, gdp, mgr and ren are carbon dioxide emissions, greenhouse gas, consumer price index, real gross domestic product, migration index, and renewables respectively. *P-value* is the probability value.