
The Moderating Role of Employment in an Environmental Kuznets Curve Framework Revisited in G7 Countries

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Abstract: Anthropogenic activities have resulted in environmental concerns due to the global consciousness for mitigating climate change issues. This awareness is emphasized in the sustainable development goals contained in the seventh and 13th targets. The study investigates the nexus between energy and growth while considering the moderating role of employment and its interaction with energy consumption in G7 countries for the period of 1980–2018. To achieve this objective, a carbon-income function is fitted to ameliorate the problems related to omitted variable bias. Empirical results indicate that all outlined variables are cointegrated over the investigated period, as reported by the Kao cointegration test. The study further validates the environmental Kuznets curve (EKC) hypothesis in the short-run. With emphasis on economic growth relative to environmental quality while in the long run, there is no statistical evidence in support of the EKC phenomenon. Furthermore, a 1% increase in energy consumption increases pollutant emission in the long run by 3.80%. Similarly, a positive elastic relationship is observed between trade and environmental degradation. This outcome is demonstrated in the causality results, which reveal a one-way causality running from trade to pollutant emission. These findings provide insights that can help policy formulations, including decoupling economic growth from pollutant emission and the need to adopt cleaner and eco-friendly technologies.

Keywords: EKC, employment, heterogeneous panel causality, PMG-ARDL, pollutant emission.

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INTRODUCTION

Studies on the energy–environmental climate association and its adverse impact has generated a lot of interest and discourse in the energy economics literature.¹ Eco-friendly pollution and environment changes in many nations has being the center of examination for many academics and focus of all stakeholders in the world. Environmental Kuznets curve (EKC) hypothesis is highlighted as a prominent approach for examining the adverse effects of negative economic events in contamination or environment modification (Al-Mulali et al., 2016; Bekun et al., 2019a, 2019b; Ozturk & Acaravci, 2010; Ozturk & Bicimveren, 2018; Saboori et al., 2016; Shahbaz et al., 2013, 2012). There is evidence supporting the research on the involvement of energy use and macro-economic engagement in greenhouse emissions and environmental degradation in modern countries (Adedoyin et al., 2020). Moreover, some studies have found the U-shaped EKC for nations, whereas others have found the reversed U-shaped EKC.

This study complements extant literature by analyzing the measure and implications of higher job rates on greenhouse gases. Specifically, by analyzing increased fuel and oil usage in the G7 countries which comprise of United States of America, United Kingdom, Japan, Italy, Germany, France, and Canada. World data on CO₂ emission, place these countries among the top 25 carbon emission countries (www.usatoday.com). The USA ranks second among countries generating the most CO₂ emissions with 5269.3 million metric tons annually. Japan emerges number five with 1205.1 million metric tons. Number six is Germany with 799.4 million metric tons of production of CO₂, the tenth is Canada with 572.8 million metric tons, and the United Kingdom produced 386.3 million metric tons and is number 17 on the list, France is number 18 with the production of 356.3 million metric tons and Italy produced 355.45 million metric tons of CO₂ emission. An implication of the above detailed CO₂ emissions by these countries, is that, it points out the fact that these states are highly industrialized, therefore they are likely to produce much CO₂ emission. Further, given the high levels of industrialization, there is also the possibility of a high employment rate to compensate the industrial production.

The World Bank statistical data index on employment rates proportionate to gross domestic product (GDP) showed as, Canada's total employment was 4.5%, France had 4.2% of the total employment, Germany had 4.3% of total employment, Japan owned 2%, the USA had 2.5% and United Kingdom also had 2.4% of total employment to GDP (World Bank, 2019). It is therefore inferred that, highly industrialized countries would have high employment rates to GDP and given the enormous industries they may have problems with CO₂ emissions. As a way of reducing environmental degradation, this study investigates how significant the employed population of G7 countries contribute to the production of CO₂ emission and suggest strategies to reduce it. Based on prior studies reviewed for this study, this study is the first of its kind, thus, considering an investigation in the consequences of carbon emissions and income function while accounting for more co-variables ignored in the literature. The rest of this study follows: Methods explains the materials and methods used. Results and discussion presents empirical results and discussion while conclusion presents the concluding remarks.

METHODS

The authors argue that, growth in terms of creating more employment avenues for citizens of a country has significant effects on energy consumption, this assertion similarly holds particularly true for G7 countries

1. For the want of space, the energy-growth literature holds four hypotheses namely: (i) growth literature, (ii) conservative hypothesis, (iii) feedback hypothesis, and (iv) neutrality hypothesis (see Ozturk, 2010).

(Canada, France, Germany, Italy, Japan, UK, and USA) who are currently touted as the great seven countries in the world. GDP is interconnected with this nexus; the long-term shape of the EKC should be regarded as a functional simulation technique in Equations (1) and (2). Equation (1) includes the EKC with the effect of repressors as the main effect function, where Equation (2) includes the interaction effect of higher employment rate and energy consumption nexus.

Main effect function:

$$CO_{2t} = f(GDP_t, GDP_t^2, EC_t, EMP_t, TRD_t) \quad (1)$$

Interaction effects' function:

$$CO_{2t} = f(GDP_t, GDP_t^2, EC_t, EMP_t, TRD_t, EMP_t \cdot EC_t) \quad (2)$$

Where carbon dioxide emission (CO_2), energy consumption (EC), employment (EMP), and trade (TRD) within the main effect in equation (1) and within the interaction terms of $EMP \cdot EC$ in equation (2).

The practical relationship in equations (1) and (2) can be articulated in logarithmic form to model the growth influences;

Key effect exemplary:

$$\ln CO_{2t} = \beta_0 + \beta_1 \ln GDP_t + \beta_2 \ln GDP_{2t} + \beta_3 \ln EC_t + \beta_4 EMP_t + \beta_5 TRD_t + \varepsilon_t \quad (3)$$

Interaction effects' model:

$$\begin{aligned} \ln CO_{2t} = & \beta_0 + \beta_1 \ln GDP_t + \beta_2 \ln GDP_{2t} + \beta_3 \ln EC_t \\ & + \beta_4 \ln EMP_t + \beta_5 TRD_t + \beta_6 EMP \cdot EC_t + \varepsilon_t \end{aligned} \quad (4)$$

where at the period year represent t , $\ln CO_2$ is the ordinary log of carbon dioxide emission, $\ln GDP$ is the ordinary GDP, $\ln GDP^2$ is the ordinary log of squared GDP growth as per expected in the EKC concept, $\ln EC$ is the log of intake energy, $\ln EMP$ is the ordinary log of the employment rate percentage, $\ln TRD$ is the log natural trade, $\ln EMP \cdot EC$ (found in equation (2)) is the ordinary log of collaboration terms among the percentage of employment and intake of energy and ε is the error term. All data were sourced from the World Bank database from 1990 to 2018.

RESULTS AND DISCUSSION

This section provides the discussion of all empirical results and discussions accordingly. Table 1 shows that pollutant emission has the highest average over the period under consideration. All series were negatively skewed with the exception of pollutant emission, while the Pearson pairwise correlations shows that CO_2 emission significantly correlates with economic growth and all the control variables examined.

As a next step, to deal with the problem of multicollinearity among the selected variables, the variance inflation factor (VIF) or tolerance factor estimation was employed as reported in Table 2. The VIF table shows a threshold less than 10 for all examined variables. Thus, suggestion no threat of possibility of multicollinearity issues. Furthermore, the Dickey and Fuller (ADF) (1981) estimation was used to access the stationary properties among the variables considered. Kao's (1999) residual cointegration test was used to determine the long-run equilibrium relationship between the variables in both equations (1) and (2). The PMG-ARDL test was employed to assess both the short- and long-run elasticity of CO_2 with the control variables. Finally, the direction of causality is explored by Dumitrescu and Hurlin (2012) heterogeneous causality test.

Table 1. Descriptive/Correlation Matrix Analysis

	LnCO ₂	LnGDP	LnGDP ²	LnEC	LnEMP	LnTRD	LnEMP_EC
Mean	2.297674	0.587983	1.020965	1.866631	1.405163	3.794827	2.172382
Median	2.245845	0.667541	1.337065	1.840130	1.473618	3.915519	2.141780
Maximum	3.004630	1.926962	3.853923	3.122420	1.991703	4.484931	3.725001
Minimum	1.520209	-2.137132	-10.78634	-0.497146	0.680568	2.773456	-0.181104
Std. Dev.	0.400264	0.684908	1.838486	0.858430	0.355629	0.432141	0.996152
Skewness	0.269221	-1.182228	-2.134564	-0.586680	-0.046518	-0.654106	-0.336170
Kurtosis	2.000168	5.183287	11.30795	3.080138	1.958484	2.441375	2.490370
Observations	203	203	203	203	203	203	203

	LnCO ₂	LnGDP	LnGDP ²	LnEC	LnEMP	LnTRD	LnEMP_EC
LnCO ₂	1						
LnGDP	0.2903***	1					
LnGDP ²	0.2189***	0.6477***	1				
LnEC	0.0946	-0.0701	-0.0215	1			
LnEMP	-0.1764***	-0.0972	-0.0517	0.4078***	1		
LnTRD	-0.2755***	-0.0197	0.0591	0.3691***	0.4915***	1	
LnEMP_EC	0.0386	-0.0775	-0.0256	0.9688***	0.6189**	0.4519***	1

Notes: ***, **, and * are 1%, 5%, and 10% significant levels, respectively

Table 2. VIF Estimations

Variable	VIF	1/VIF
LnGDP	1.74	0.574715
LnGDP ²	1.74	0.574490
LnEMP	1.44	0.692999
LnTRD	1.40	0.716350
LnEC	1.26	0.794776
Mean VIF	1.52	

Source: authors computation

The variance inflation factor (VIF) or tolerance factor from Table 2 proves that, as the mean VIF which is 1.52, there is no problem of multicollinearity among the selected variables. Therefore, the problem of spurious level of the variables has been checked by the study. From this point it was valid for the study to proceed to estimate for the unit root.

From Table 3, it is evident that, at the level, the variables were not significant, thus, there was no stationarity among them but at the first difference there was stationarity among the variables. Having stationarity presents the need to test for cointegration in equations (1) and (2) using the Kao residual cointegration test.

The results from the cointegration test (see Table 4) suggests there is cointegration at 10% in both the main and the interaction effect. Again, in order to validate the accuracy and robustness of the tests, the PMG-ARDL technique was employed to establish both the short-run and long-run relationships regarding CO₂ emission and the selected control variables. The convergence of the fitted model is seen by convergence of 11.29% on an annual basis by the contribution of the regressors (Table 5). From the estimation it shows that economic growth exerts a positive elastic impact on pollutant emissions in the short run. This indicates that

Table 3. Unit Root Test

Statistics (Level)	LnCO ₂	LnGDP	LnEC	LnEMP	LnTRD
$\pi\tau$	0.7214***	0.0000***	0.9007	0.7949	0.8506
$\pi\vartheta$	0.0044***	0.0000**	0.8225	0.2707	0.6029*

Statistics (1st difference)	Δ LnCO ₂	Δ LnGDP	Δ LnEC	Δ LnEMP	Δ LnTRD
$\pi\tau$	0.0000	0.0000***	0.0002***	0.0034***	0.0009***
$\pi\vartheta$	0.0000	0.0000***	0.0013***	0.0013**	0.0056***

Notes: ***, **, and * are 1%, 5%, and 10% significant levels, respectively; thus, $\pi\tau$ is with constant, $\pi\vartheta$ is with constant and trend

Table 4. Cointegration Tests

Kao Residual Cointegration Test			
Variables	t-stat	Prob	Conclusion
Main effects: LnCO ₂ = f(LnGDP, LnGDP ² , LnEC, LnEMP, LnTRD)	-1.371622*	(0.0851)	There is cointegration
Interaction effect: LnCO ₂ = f(LnGDP, LnGDP ² , LnEC, LnEMP, LnTRD, LnEMP_EC)	-1.459003*	(0.0723)	There is cointegration

Notes: ***, **, and * are 1%, 5%, and 10% significant levels, respectively

Table 5. PMG-ARDL for Long- and Short-Run for CO₂ Emission

Variables	Coefficient	Std. Error	T-Statistic
Long Run			
LnGDP	-0.22718***	0.021137	-10.7479
LnGDP ²	-0.034494**	0.015565	-2.216161
LnEC	3.800691***	0.988257	3.845855
LnTRD	0.752097***	0.148244	5.073354
LnEMP	2.620418***	0.692907	3.781775
LnEMP_EC	-4.244105***	1.035500	-4.098604
Short Run			
COINTEQ01	-0.112900***	0.00840	-13.4405
D(LnGDP)	0.010510**	0.004917	2.137654
D(LnGDP ²)	-0.001420	0.002856	-0.497235
D(LnEC)	10.34896	10.47457	0.988008
D(LnTRD)	-0.011860	0.084175	-0.140902
D(LnEMP)	6.049165	5.424808	1.115093
D(LnEMP_EC)	-10.46237	10.44157	-1.001992
Constant	-0.280659	0.173594	-1.616751

Notes: ***, **, and * are 1%, 5%, and 10% significant levels, respectively

growth trajectory in the G7 economics increases pollutant emission. The current study further validates the EKC hypothesis in the short run. Thus, implying the regions emphasis on economic growth at the expense of quality of the environment (Gyamfi et al., 2020; Ozturk et al., 2010). Further, the empirical result shows that energy consumption, trade openness and employment percentage to total population were all positive and significant at 1% statistical rejection level with exception of energy consumption and employment percentage to total population which had a negative significance also at 1% level.

Table 6. Heterogenous Panel Causality Test

Null Hypothesis:	Zbar Stat	p-value
$\text{LnGDP} \neq \text{LnCO}_2$	-0.13363	(0.8937)
$\text{LnCO}_2 \neq \text{LnGDP}$	-0.01385	(0.9890)
$\text{LnGDP}^2 \neq \text{LnCO}_2$	4.01580***	(6.E-05)
$\text{LnCO}_2 \neq \text{LnGDP}^2$	0.14551	(0.8843)
$\text{LnTRD} \neq \text{LnCO}_2$	3.41644***	(0.0006)
$\text{LnCO}_2 \neq \text{LnTRD}$	1.40883	(0.1589)
$\text{LnEMP} \neq \text{LnCO}_2$	8.45003***	(0.0000)
$\text{LnCO}_2 \neq \text{LnEMP}$	3.84819***	(0.0001)
$\text{LnEMP_EC} \neq \text{LnCO}_2$	3.14547***	(0.0017)
$\text{LnCO}_2 \neq \text{LnEMP_EC}$	2.20617**	(0.0274)
$\text{LnEC} \neq \text{LnCO}_2$	4.31335***	(2.E-05)
$\text{LnCO}_2 \neq \text{LnEC}$	2.49715**	(0.0125)

Notes: ***, **, and * are 1%, 5%, and 10% significant levels, respectively, while $\neq$ denote does not “Granger cause”

From the short-run estimation of the same PMG-ARDL, it was clear that, pollution emission was significant at 10%. Furthermore, the presence of EKC was to establish that GDP was significant at 5% but when it is squared the GDP is proved to have no significance. This indicates that the short-run GDP is a contribution factor to CO₂ pollution but when it rises to a certain extent the pollution reduces and then disappears for some time. While in the long-run analysis, this study fails to confirm the EKC hypothesis, which does not show a U-shaped EKC phenomenon, which is consistent with the studies of Al-Mulali et al. (2015) and Tiwari et al. (2013). Thus indicating that the investigated region is more conscious of the environment as time progresses.

Subsequently, after assessing the long- and short-term elasticity within the variables, it was quite crucial to know if the causality exist between the variables. For this function, we submitted the Dumitrescu and Hurlin (2012) causality. The crucial aspect of this approach is that it adopts all the factor variables to be stationary, which are cross-section variations.

The analysis from Table 6 shows a bi-directional causality between employment percentage of the total population and CO₂ pollution, then energy consumption and employment percentage of the total population and CO₂ pollution. Furthermore, there is a unidirectional causality among GDP square and pollution emission, trade openness and CO₂ pollution and energy consumption and CO₂ emissions. All aforementioned causality analysis have far-reaching implications. For instance, causality between pollutant emissions, employment, and energy consumption economic growth implies that economic growth is a good predictor of pollutant emission. These outcomes are an appropriate guide for policymakers and all stakeholders alike.

CONCLUSION

This study examines the moderating role of employment in Environmental Kuznets Curve framework in G7 countries. During the 1990s these countries invested much into establishing industries to help increase the employment opportunities for their citizens. This model of industrialization used by these countries has brought economic value to different sectors in their economies, especially the energy sector. By applying the PMG-ARDL econometric techniques, it is revealed that the U-shape EKC was not established for the G7 countries in the long run but was established in the short run. Proof from the analysis shows that both employment and energy use are significant in long term with respect to CO₂ emission as reported by the PMG-ARDL. Furthermore, in the

short run the U-shape EKC was observed from the GDP and GDP² production of CO₂ pollution. There was a bi-directional causality among employment percentage of the total population and CO₂ pollution as well as collaboration of intake of energy and employment percentage of the total population and CO₂ pollution and unidirectional causality among GDP square and CO₂ pollution, trade openness and CO₂ pollution and intake of energy and CO₂ pollution.

Additional empirical examinations reveal that, the employment proportion of the population from the various countries within the G7 states are major contributors to environmental degradation in the form of CO₂ emissions. By implication, human industrial activities are a major contribution to CO₂ pollution. It is therefore advisable for these countries to look in the employment activities undertaken by the employed population that increase CO₂ pollution in these countries. Thus, it is therefore not advisable for the countries to invest much in machines and other industrial equipment which produce more CO₂ pollution. Conclusively, new innovations and technologies should be employed to help reduce high CO₂ emission in the investigated region. Furthermore, in these countries of huge industries, environmental planning and policies in the industrial sectors should be part of the environmental and energy policies.

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