Appiah, Kingsley; Du, Jianguo; Yeboah, Michael et al.

Article

Causal relationship between industrialization, energy intensity, economic growth and carbon dioxide emissions : recent evidence from Uganda

Reference: Appiah, Kingsley/Du, Jianguo et. al. (2019). Causal relationship between industrialization, energy intensity, economic growth and carbon dioxide emissions : recent evidence from Uganda. In: International Journal of Energy Economics and Policy 9 (2), S. 237 - 245.
doi:10.32479/ijeep.7420.

IJEEP
INTERNATIONAL JOURNAL OF ENERGY ECONOMICS AND POLICY
EJ EconJournals
ISSN: 2146-4553

International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2019, 9(2), 237-245.

EJ EconJournals

Causal Relationship between Industrialization, Energy Intensity, Economic Growth and Carbon Dioxide Emissions: Recent Evidence from Uganda

Kingsley Appiah[1,2], Jianguo Du[1]*, Michael Yeboah[2], Rhoda Appiah[3]

[1]School of Management, Jiangsu University, Zhenjiang 212013, P. R China, [2]Department of Accountancy, Kumasi Technical University, Box 854, Kumasi, Ghana, [3]Administration, Community Special Vocational School, Deduako-Kumasi, Ghana. *Email: jd_foreign_phd@163.com

Received: 03 December 2018 **Accepted:** 06 February 2019 **DOI:** https://doi.org/10.32479/ijeep.7420

ABSTRACT

With Uganda's desire to industrialize for economic transformation and development comes with negative effect on environment as carbon emissions increases. Our study used econometric approach to perform empirical analysis to arrive at our findings on causal correlation between carbon dioxide emissions (CO_2), energy intensity, industrialization, and economic expansion in Uganda for the period 1990 to 2014 using autoregressive distributed lag (ARDL) approach. In the long-run, economic growth and industrialization increase of 1% each increase carbon emission by 31.1% and 3.2% respectively while 1% increase in energy intensity decrease emission by 83.9%. Results of ARDL shows that, joint effect of energy intensity, economic progress and industrialization at constant decrease emissions by 2.46% in Uganda. In the pursuit of carbon emissions mitigation in Uganda, there is the need to increase energy intensity to reduce emissions level in the long-run. This requires the need to undertake wide-ranging of policy and institutional reforms.

Keywords: Carbon Dioxide, Autoregressive Distributed Lag, Variance Decomposition, Impulse Response Function
JEL Classification: O44, Q51, Q56

1. INTRODUCTION

Recent climate change has had a universal impact on living species and natural systems. The impact of global climate change affects weather patterns and also increase climate events as droughts, hurricanes and floods (Appiah et al., 2017).The anthropogenic emissions of greenhouse-gases from pre-industrial time has led to significant increase in concentration of pollutants in the atmosphere. However, among the environmental contaminants, carbon dioxide emissions have received international attention due to their global environmental impact (Friedlingstein et al., 2010; Tang and Tan, 2015). Two key sources that are well-thought-out as the main cause of carbon emissions globally, is combustion of fossil fuel and industrial processes. Carbon dioxide emission through burning of hydrocarbon deposits has been proven to have direct link with increasing energy intensity, economic activity and increase in population size, whiles increase in industrialization also causes emissions as results of industrial processes. In Uganda, CO_2 emissions from hydrocarbons deposits combustion and industrial practices contribute approximately 0.099% of global carbon stock. Although Uganda has contributed less to the potentially catastrophic accumulation of man-made carbon footprint, however, the country is vulnerable to the impacts of climate change. Uganda has the lowest carbon stock in the world, which is estimated at 1.39 tons of CO_2 below the world average of about 7.99 tons of carbon emissions per capita (Environment, 2015).

In order to complement global effort to reduce the negative impact of climate change on human and environment, Uganda government has launched its National Greenhouse Gas (GHG) Inventory Scheme based on Paris Agreement for Climate Change. The main source for the provision of energy for the majority of Ugandan is biomass. The use of biomass includes firewood providing 78.6% of the energy needs of Ugandans, charcoal (5.6%) and crop residues (4.7%). On other hand, electricity also provides 1.4% of Ugandans energy needs whiles the remaining percent of 9.7 from the use of oil products to power thermal plants and vehicles (International Energy Agency, 2017). The reliance on the use of biomass as the main energy sources makes it difficult for Uganda to achieve Sustainable Development Goal (SDG) 7 and 13. The negative effect of Climate Change is very high on developing countries as Uganda and therefore, its increase will amplify the current economic, natural and human species difficulties globally. For Ugandans to achieve SDG 13 need to ensure substantial reductions of emissions through proper strategic adaption and mitigation policies. There is the need to look causal connection between energy intensity, industrialization, economic growth and environmental pollution It is however unfortunate that studies on environment of Uganda has not received the needed attention and therefore, study as this will bring to light energy intensity level, industrialization and economic growth impact on Ugandan environment. This will make it easy for policy formulation and implementation to mitigate effect of environmental degradation. Our study seek to extend similar studies of (Ashraf et al., 2013; Onakoya et al., 2013; Aslan, 2014; Sekantsi and Okot, 2016). The study emanates to provide empirical results to deal with climate change which has become global concern from Uganda perspective. The advent of various econometric methods has romped significant role in the revelation of scientific proof of the causal relationship between various variables and ecological pollution in different countries both developed and developing once. Yet, literature is scanty in the case of Uganda and therefore, our study makes an attempt to investigate the causal relationship between industrialization, energy intensity, economic advancement and carbon dioxide emissions.

The rest of our work is as follows. Section 2 would deal with the relevant literature, while the data and methodology used by the paper for analysis would be revealed in Section 3. Section 4 would present the data and empirical results of our study. The conclusion and policy recommendations will be presented in our last section 5.

2. LITERATURE REVIEW

2.1. Energy Intensity-growth-carbon Dioxide Emissions Nexus

Energy Intensity is considered as a useful measure of energy consumption of an economy which translate to how efficient economies are able to create own electricity. Therefore, reduction in energy intensity of an economy not only boost economic prosperity but also help to reduce harmful environmental impacts. At early stage of industrialization in an economy causes an increase in energy intensity but with serious environmental protectionism and monitoring of the industries activity can help to reduce energy intensity. (Liu et al., 2011) investigated the linkage between output, energy intensity, urbanization and CO_2 emissions in China. The study applied three different urbanization policy implication to forecast the carbon emissions in China. The study findings based on econometric model indicates any adjustment to the energy structure and technical novelty have policy implications in China. They therefore concluded that higher level of China's urbanization; energy intensity and energy carbon emission coefficients have direct effect of increasing carbon emissions in China depending on regional and provincial level under consideration. On other hand, (Wang et al., 2012) also conducted similar study to find the linkage among energy concentration, urbanization, output and CO_2 emissions in Minhang District, Shanghai. Using STIRPAT model. The study findings indicates that population increases, affluence and urbanization contribute directly to an increase in carbon emission but however findings on energy intensity and emissions relations nexus revealed that energy intensity reduces carbon dioxide emissions. The study recommended some strategic plans to reduce future energy intensity through the adaptation of lifestyle changes, structural reforms on energy resources and enhancement of transport systems (Hatzigeorgiou et al., 2011). Study in Greece from 1977 to 2007 meant to find the causal link between variables such as CO_2 emissions, GDP and energy intensity. Using Johansen cointegration and Vector Error Correction, the study found unidirectional causal relationship that runs from GDP to energy intensity and also from GDP to CO_2 emissions. Empirical findings also shows bidirectional connection between CO_2 emissions and intensity of energy use. The bi-directional findings between the variables indicates that Greece as a country need to have more efficient energy system in order to curb the emissions (Lin et al., 2015) also found energy intensity to have positive but weak impact on CO_2 emission (Lin et al., 2016) considered energy structure and energy intensity as two main driving factors of Africa CO_2 emissions. Therefore, Africa countries should focus on the use of clean energy, encourage energy efficiency to mitigate the negative effect on environment.

(Sekantsi and Okot, 2016) on other hand, conducted a study in Uganda to examine association between electricity usage and economic expansion from 1981 to 2013. Through the use bounds test approach, the study found a long term nexus between the variables. Granger causality test analysis confirms that conservation hypothesis exist in the short run, that is, unidirectional causation flow from economic revolution to electricity usage in Uganda whiles feedback proposition prevails in the long run (Asumadu-Sarkodie and Owusu, 2016). Also applied autoregressive distributed lag (ARDL) approach to undertake similar study in Benin by introducing industrialization into the nexus to find the causal relationship between emission, electricity use and economic progress. The study findings indicate that carbon emissions increases in Benin by 0.56% and 0.95% when the electricity consumption changes by 1% in the short run and long run respectively. However, 1% increase in industrialization has 0.60% contribution to carbon emissions in long run in Benin. The study employed time series data of (Bank, 2017) and (US Energy Information Administration, 2015) for the period 1980-2012. Causality results shows unidirectional causality that runs from carbon emissions to economic expansion, industrialization to economic growth, electricity consumption to carbon dioxide and also from electricity consumption to economic growth (Asumadu-Sarkodie and Owusu, 2017) further explores causal association between the variables in Sierra Leone from 1980 to 2011 using Linear Regression Method and vector error correction model (VECM). The study further applied variance decomposition test using Cholesky technique due to the inability of the Linear Regression Method and VECM model to account for random innovations. Findings indicate long run relationship between the variables with some future shocks to variables. Analysis of the variance decomposition revealed electricity consumption future shock of 7% to carbon dioxide whiles industrialization caused 3% future shock to electricity consumption. In the same vain, economic growth caused 48% future shock to industrialization whiles 20% in economic growth is produced by carbon dioxide.

Economic growth and environmental pollution nexus is considered as one of the universal research nexus that have been taken by so many researchers (Esso, 2010; Narayan and Narayan, 2010; Alam et al., 2012, Arouri et al., 2012; Michieka et al., 2013; Mensah, 2014, Charfeddine and Khediri, 2016; Bilgili et al., 2017; Elliott et al., 2017; Setiartiti, 2018). Some found economic growth as the main cause of environmental pollutions (Ang, 2007, Mensah, 2014, Lin et al., 2015; Elliott et al., 2017; Huang et al., 2017) whiles others hold contrary view (Ghosh, 2010; Ozturk and Acaravci, 2010; Alam et al., 2011, Lim et al., 2014). (Aye and Edoja, 2017) applied dynamic panel threshold framework of 31 developing countries. The results of their study attest to other researchers findings that economic growth contribute to environmental pollution. That is, economic growth has negative effect on CO_2 emission particularly when the growth is low but economic growth however exhibits positive effect when growth is high. (Elliott et al., 2017) also provide an affirmation that is backing the view that economic growth positively affects the energy intensity of a country whiles examining the effect of urbanization on intensity of energy use in China. (Mensah, 2014) examined carbon emissions, energy use and real output of six African emerging economies causal dynamics of the variables. Findings confirms the presence long run effect of carbon emissions and economic progress on energy use in Ghana whiles economic growth is seen as positive driving force of energy consumption of economies as South Africa, Ghana and Kenya. Unidirectional causality was found to run from economic growth to carbon dioxide emissions of countries like Nigeria, Senegal and Egypt.

2.2. Industrialization - Carbon Dioxide Emissions Relationship

Industrialization is a term that usually refers to an increase in industrial activity and most authors assume that industrialization leads to higher energy usage because higher value added manufacturing uses more energy than does traditional agriculture or basic manufacturing (Sadorsky, 2014) (Lin et al., 2015). Investigated the impact of industrialization-led economy effect on environmental sustainability in developing country like Nigeria. Using Kaya Identity framework for the period 1980–2011. Findings indicates that industrial value added of Nigeria economy has an inverse but significant effect on the relationship with CO_2 emissions meaning no substantial proof that industrialization increase the emissions level in Nigeria. (Raheem and Ogebe, 2017) investigated the effect of urbanization and industrial value on CO_2 emissions in 20 African states from 1980-2013. Unexpectedly, the findings of effects of industrialization and urbanization on CO_2 can be seen in direct and indirect ways. In direct sense, the study found industrialization and urbanization to increase environmental degradations whiles indirectly the two variables were found to decrease environmental degradation. That is, at a certain point indirect effect of industrialization will swarmed the direct effect leading to a reduction of environmental degradation.

3. MATERIALS AND METHODS

3.1. Data Collections and Variable Definitions

The study examined the causal nexus among the variables. To approach the analysis of our study, time series dataset were put together from World Bank (2016) from 1990 to 2014. The data includes CO_2, CO_2 emissions (metric tons per capita) as proxy of outcome variable; ENI, Energy intensity (MJ/$ 2011 PPP GDP); GDP, GDP per capita (current US$) as proxy of economic growth and IND, Industry value added (% of GDP) as proxy for industrialization. ENI, GDP and IND are the predicting variables used in the analysis (Table 1).

3.2. Descriptive Analysis

Descriptive statistical analysis is very important, since it describes the features of the data of the untreated time series. Table 2 presents a descriptive analysis. While CO2, ENI and GDP are positively skewed, IND is negatively skewed. However, CO2, ENI, GDP and IND show the distribution of leptokurtic. Based on the level of significance of 5%, the null theory of the normal distribution according to the Jarque-Bera statistics is accepted, therefore, CO2, ENI, GDP and IND are normally distributed.

3.3. Empirical Model

In order to examine causal correlation between the dependent (CO_2) and predicting variables (ENI, GDP and IND), our study adopted (Sarkodie and Owusu 2017) model to formulate the basic framework for the analysis as:

$$CO_{2t}=f(ENI, GDP, IND)_t \quad (1)$$

Where *ENI, GDP* and *IND* represents Energy Intensity, Economic growth and Industrialization respectively. To reduce multiplicative relationship to an addictive one requires the need to take the natural logarithms of the variables in Equation (1) and therefore our Log-log linear connection between carbon dioxide emission, Energy Intensity, Economic Growth and Industrialization expressed as follows:

$$\log CO_{2t}=\alpha+\beta_1\log ENI+\beta_2\log GDP+\beta_3\log IND_t+\varepsilon_t \quad (2)$$

Where α is the constant, β_1, β_2 and β_3 are the coefficient of ENI, GDP and IND respectively. ε_t also represent the white noise of the analysis.

3.4. Methodology

Prior to determination of cointegration relationship among the variables is to test for unit root. The study therefore employed

Table 1: Data collection and definitions

Abbreviation	Variable name	Unit	Sources
CO_2	CO_2 emissions	Metric tons per capita	WDI 2016
ENI	Energy intensity level of primary energy	MJ/$ 2011 PPP GDP	WDI 2016
GDP	GDP per capita	Current US$	WDI 2016
IND	Industry value added	% of GDP	WDI 2016

Table 2: Descriptive statistical analysis

Statistic	CO_2	ENI	GDP	IND
Mean	−2.6907	2.4911	5.7774	2.9732
Median	−2.8034	2.4959	5.6584	3.0502
Maximum	−2.0210	3.0386	6.5781	3.5327
Minimum	−3.3367	1.9500	5.0316	2.4031
Std. Dev.	0.4101	0.3463	0.4597	0.2836
Skewness	0.2587	0.0379	0.4012	−0.3484
Kurtosis	1.7380	1.7690	2.0508	2.3863
Jarque-Bera	1.9377	1.5844	1.6091	0.8983
Probability	0.3795	0.4528	0.4472	0.6381

Augmented Dickey-Fuller (ADF); and Philips and Perron (PP) test to perform this key function. However, time series data such as ours most of the time produces non-stationary results at level. ARDL would be used whether variables are integrated at same order or not. Dynamic ordinary least square regression would be applied to determine the coefficient and long-run relationship between the variables. To find cause-effect relationship between variables, we performed Granger causality to test for direction of causation. To ensure robustness of the analysis, stability and residual test would be perform using inverse root of AR characteristic polynomial. To achieve an empirical results, our study scrutinize the stochastic procedure using econometric analysis. To assess model normality, the study applied Jarque-Bera test. To detect if nonlinear mixture of predicted values help to give details of outcome variable, our study applied the regression specification error test (RESET) of Ramsey (1969).

3.5. ARDL Co-integration Analysis

To examine co-integration relationship between variables, bounds test was employed with the view of determining co-integration within ARDL modeling technique. The application of ARDL/Bounds testing methodology is preferred to the conventional cointegration due to some of the characteristics associated with it. Firstly, the adoption of ARDL is firstly based on the fact that this method is applicable whether the variables are integrated at the same order or not. That is, some of the variables might be stationary at level, first difference or fractionally integrated. Secondly, ARDL involves setting-up single equation to perform the analysis which makes interpretation and implementation easy. Thirdly, ARDL offers unbiased long-run approximations and useable statistical values (i.e., t-statistics). Finally, different lag-lengths can be used with same model to different variable. Finally, ARDL techniques helps in derivation of dynamic unrestricted error correction model which intend also help in determination of short-and long-term without losing relevant data.

3.6. VECM

After satisfying pre-condition of ARDL bounds test approach, the study follows work of (Asumadu-Sarkodie and Owusu, 2017) to estimate the long-run coefficients the study, which is expressed as:

$$(1-L)\begin{bmatrix} CO_{2t} \\ ENI_t \\ GDP_t \\ IND_t \end{bmatrix} = \begin{bmatrix} \alpha_1 \\ \alpha_2 \\ \alpha_3 \\ \alpha_4 \end{bmatrix} + \sum_{i=1}^{q}(1-L)\begin{bmatrix} \beta_{11t} & \beta_{12i} & \beta_{13i} & \beta_{14i} \\ \beta_{21i} & \beta_{22i} & \beta_{23i} & \beta_{24i} \\ \beta_{31i} & \beta_{32i} & \beta_{33i} & \beta_{34i} \\ \beta_{41i} & \beta_{42i} & \beta_{43i} & \beta_{44i} \end{bmatrix} \times \begin{bmatrix} CO_{2t-i} \\ ENI_{t-i} \\ GDP_{t-i} \\ IND_{t-i} \end{bmatrix} + \begin{bmatrix} \lambda_1 \\ \lambda_2 \\ \lambda_3 \\ \lambda_4 \end{bmatrix}[ECT_t - 1] + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \\ \varepsilon_{4t} \end{bmatrix} \quad (4)$$

Where (1-L) represents the change or difference operator, q is the number of lags, ECT_{t-1} denote the error correction term meant to find the integration of the variables in the long-run. The used of α's, β's and λ's are the parameters whiles ε_t's are the white noises.

3.7. Diagnostic and Stability Test

Our study successively performed the stability and residual test to ensure that the model is robust. To validate our VECM model requires the need to ensure no serial correlation in the residuals, error terms are not heteroscedastic and are normally distributed.

3.8. Granger Causality Test

The Granger causation test helps to determine the cause-effect connection between the variables. The study pragmatically used VECM to determine the long-run link between variables at 5% significance level. At significance level of 5%, ENI, GDP and IND have long-run relationship. The evidence of this is depicted in Table 3. Due to the inability of the ARDL regression to assess the direction of causality, the study used Granger's causality to evaluate the direction of causality between the variables.

3.9. The Innovative Accounting Approach & the Impulse Response Function

The application of Granger-Causality to test the direction of causality among series has its own limitation of not examining how various variables respond to random innovations in other series. Our study applied both Variance Decomposition and Impulse Response Analysis meant to overcome the inherent problem that comes after the current period and also to prevent orthogonal problems connected with the sample. That is, the Impulse Response analysis is meant to find responsiveness outcome variable in the VAR when a shock is put to error term (ε_t) in equation (2). Therefore, unit shock is applied to each of variables in order to see its effects on VAR system. Subsequently, this study predicts a causal link between carbon emissions, economic growth, energy intensity and industrialization in Uganda in the next 10 years.

4. RESULTS AND DISCUSSION

Results of the analysis depicts that the linear causal connection between variables is highly significant and no multicollinearity exist. The trend of the variables is presented in Figure 1. The Figure 1 clearly shows trend of energy intensity, economic growth, industrialization and carbon dioxide have strong relationship among them.

4.1. Unit Root Test

Our results in Table 4 indicate that both ADF and PP depicts existence of unit root at level however, data become stationary at first difference. Therefore rejected null theory at first difference that, variables at their first difference has unit root. Evidence from the unit root test suggest that the variables are non-stationary at level with a deterministic trend. However, the variables became stationary after converting them to first difference using both ADF and PP test.

4.2. Co-integration Analysis

Our unit root test results indicate that all the variables are integrated at I (1), the study selects an optimal model using the Akaike Information Criterion with optimal lag 2 depicted in Table 3. Based on selected model using Akaike Information Criterion provided ARDL (1, 0, 1, 0) as depicted in Figure 2. Using the optimal model, bounds test and co-integrating relations are shown in Table 5 the results indicate that our F-statistic value of 4.44 exceeds the critical values of upper bound at 5% and 10% significance level, therefore concluded that cointegration exist. However at 1% and 2.5% our test is inconclusive since our F-statistic falls between the bounds.

4.3. VECM

With regards to Table 6, which presents results of the short- and long-run estimates of the ARDL model shows speed of adjustment (ECT [−1] = −0.71, P = 0.00) which makes our model residuals negative but significant at 5% level. That is, speed of adjustment towards equilibrium is 71%. This means that there is long-run equilibrium relationship from ENI, GDP and IND to CO_2. The long run equilibrium connection was undertaken using F-tests based on null proposition of no cointegration between emissions, energy intensity, economic growth and industrialization (H_0: $\beta = \gamma_j = \sigma_k = \psi_L = 0$), with an alternative proposition of co-integration between CO2, ENI, GDP and IND (H_0: $\beta \neq \gamma_j \neq \sigma_k \neq \psi_L \neq 0$). The short run, relationship between response and explanatory variables was determined through the performance of Wald test. Our findings in Table 6 show that we must accept the null hypothesis that all independent variables put together cannot influence CO_2 in short-run. Therefore, no short-run causality from independent

Table 3: The optimum lag selection criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	42.34019	NA	4.19e-07	−3.333929	−3.136452	−3.284264
1	128.5172	134.8858*	9.64e-10	−9.436278	−8.448892*	−9.187953
2	148.6714	24.53549	7.79e-10*	−9.797509*	−8.020214	−9.350524*

*Indicates lag order selection by the criterion. LR: Sequential modified LR test statistic (each test at 5% level). FPE: Final prediction error, AIC: Akaike information criterion, SC: Schwarz information criterion, HQ: Hannan-Quinn information criterion

Figure 1: Trend of variables

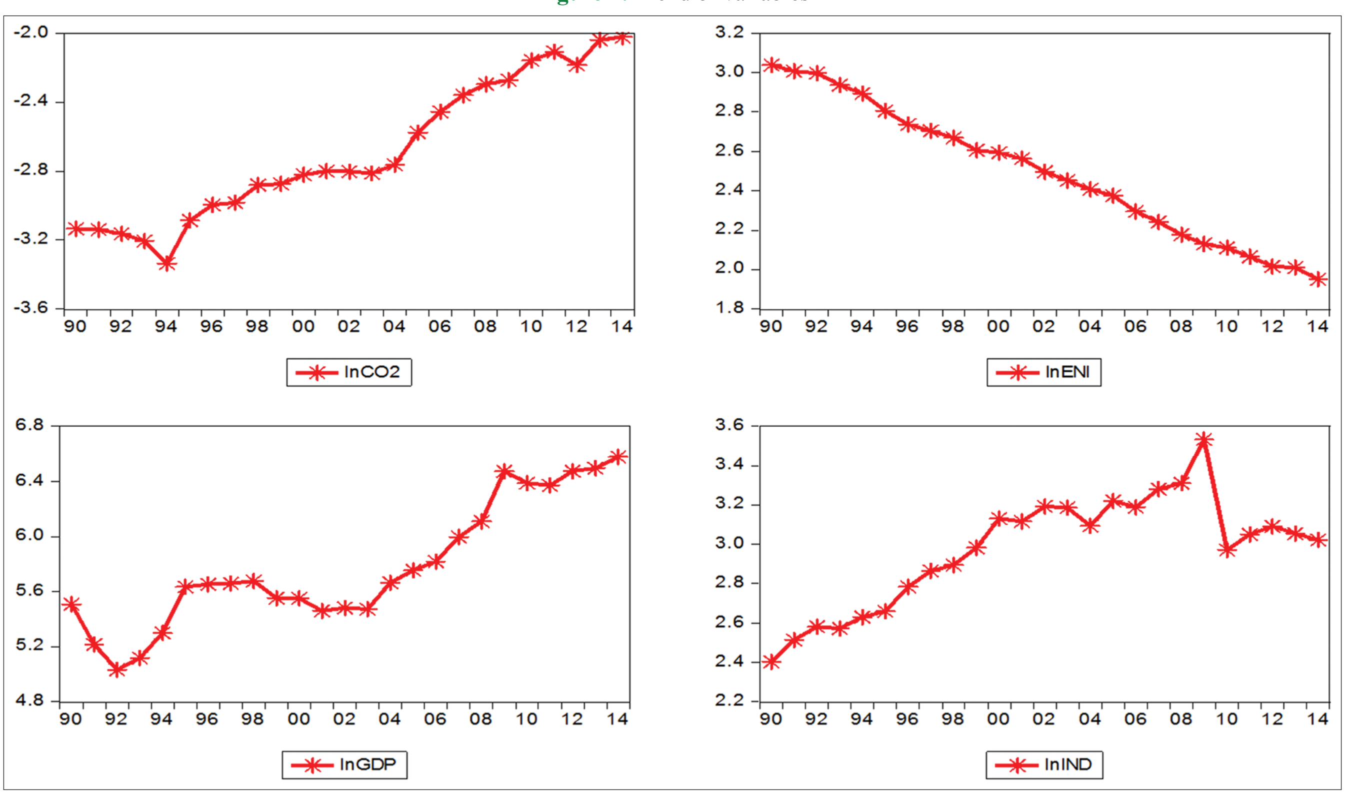
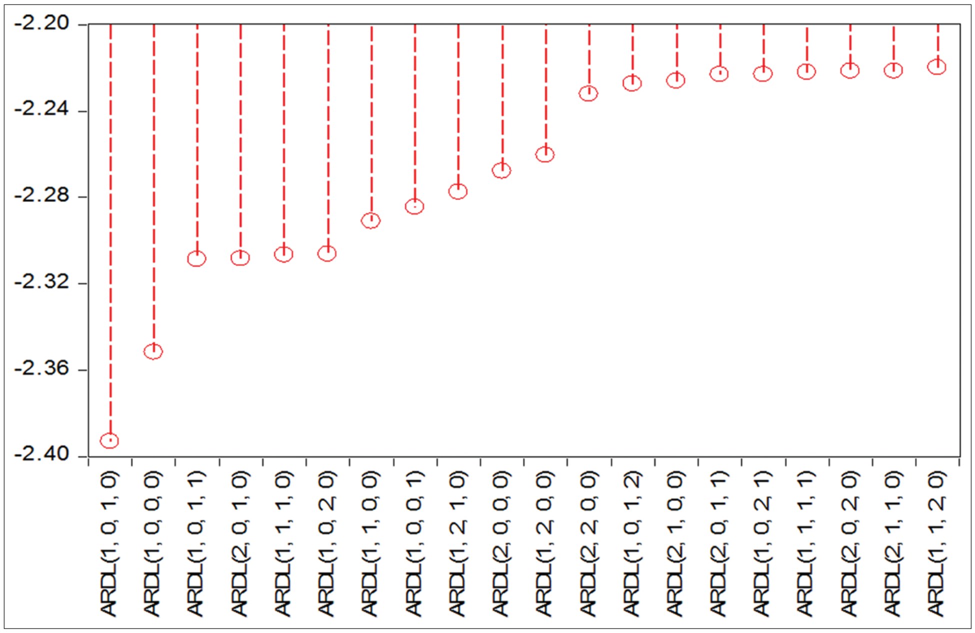


Table 4: Unit root test results

Variable	At level				At 1st difference				Integration order
	ADF		PP		ADF		PP		
	Intercept	Trend	Intercept	Trend	Intercept	Trend	Intercept	Trend	
CO_2	0.31 (0.97)	−2.91 (0.18)	0.41 (0.98)	−2.90 (0.18)	−4.79 (0.00)	−4.82 (0.00)	−4.80 (0.00)	−4.83 (0.00)	I (1)
ENI	−0.26 (0.92)	−2.52 (0.32)	−0.25 (0.92)	−2.52 (0.32)	−4.85 (0.00)	−4.77 (0.00)	−4.87 (0.00)	−4.78 (0.00)	I (1)
GDP	0.15 (0.96)	−2.50 (0.32)	−0.05 (0.94)	−2.68 (0.25)	−4.10 (0.00)	−3.92 (0.03)	−4.10 (0.00)	−3.92 (0.03)	I (1)
IND	−2.19 (0.21)	−1.71 (0.71)	−2.24 (0.20)	−1.71 (0.71)	−6.45 (0.00)	−7.02 (0.00)	−6.49 (0.00)	−10.49 (0.00)	I (1)

Figure 2: Autoregressive distributed lag model selection using akaike information criterion



variables jointly to CO_2. Additionally, same results was found that individual predictor cannot influence CO_2 in short term.

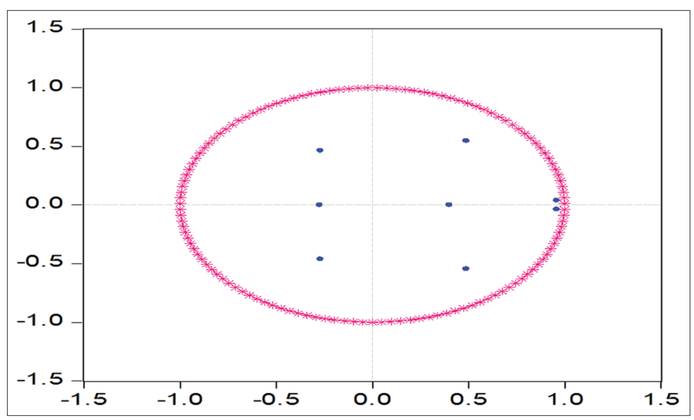
4.4. Diagnostic and Stability Test

Our findings in Table 7 postulate that residual analysis test indicates that $P > 0.05$ and therefore we accept null premise that error terms are normally distributed. Our heteroscedasticity test also accepted null assumption of no heteroscedastic effect in the model. The study serial correlation using Breuch-Godfrey Serial Correlation LM test also accepted null supposition of no serial correlation in the model with $P > 0.05$. Stability test of the model through the use of inverse root of AR polynomial as shown as Appendix A. Our results in Figure 3 show that no root falls outside unit circle thus, confirm the VAR stability conditions. The Ramsey RESET test indicate that, null premise of no omitted variables in the model cannot be rejected at 5% significance level and that no misspecifications in the model.

4.5. Granger Causality Test

Evidence from Table 8 shows that null proposition that CO_2 does not cause ENI, GDP, IND; IND does not cause CO_2, ENI, GDP; GDP does not cause ENI,IND; ENI does not cause GDP, IND were accepted. However, hypothesis that ENI does not cause CO_2; and GDP does not cause CO_2 is rejected at 5% significance level. This means that, there is evidence of unidirectional causality that comes from ENI → CO_2 and from GDP → CO_2.

Figure 3: Roots of characteristic polynomial



4.6. The Innovative Accounting Approach and the Impulse Response Function

Our study through the innovative accounting methodology in Table 9 found that in the short period (i.e., period 3) about 70.3% of carbon emissions are caused by its own standard innovation shock. Carbon dioxide emission reacts by 16.22%, 12.41% and 1.07% when a one standard deviation change is imputed in energy intensity, economic growth and industrialization, respectively. However, in the long term (i.e., period 10), 54.11% of carbon dioxide emissions are caused by own shock whiles Carbon dioxide reacts when a one standard deviation change is imputed in energy intensity, economic growth and industrialization by 21.37%, 11.28% and 13.23% respectively. Results from our innovative accounting approach indicates that increase in economic growth in Uganda would lead to an increase in carbon dioxide emissions as 1% increase in economic growth would give rise to 10.8% in carbon dioxide (periods 1–6). Results of impulse response function encapsulates the negative effects of the various independent variables on the environment of Uganda by ranking them as GDP, IND and followed by ENI as depicted in Figure 4.

5. CONCLUSIONS AND POLICY IMPLICATIONS

Our study tried to find answers to the question of whether there is causal relationship between energy intensity, economic growth, industrialization and emissions in Uganda. To achieve this, we employed time series dataset from 1990 to 2014 using ARDL cointegration approach. In addition, the study estimated Granger causality, variance decomposition and the impulse response analysis. Prior to the determination of cointegration, the study applied ADF and PP to test stationarity of the variables. Evidence of the analysis indicates that the variables are integrated at I (1). The application of bounds test was meant to determine the co-integration within ARDL modeling technique. Results of ARDL bounds test indicates that co-integration exist between variables. Based on selected optimal model using Akaike Information Criterion provided ARDL (1, 0, 1, 0) with an evidence of long-run relationship which runs from energy intensity, economic increase and industrialization to CO_2. Nevertheless, results of long run estimate of the ARDL model shows that the joint effect of energy intensity, economic growth and industrialization at constant will decrease emissions by 2.46% in Uganda. Evidence from the ARDL model estimate for short and long-run study shows that 1% increase in energy intensity will decrease carbon emissions level in Uganda by 59.2% whiles 1% increase in GDP will also

Table 5: ARDL bounds test and co-integrating relation

Test statistic	Value	K
F-statistic	4.44	3
Critical value bounds		
Significance	I0 bound	I1 bound
10%	2.72	3.77
5%	3.23	4.35
2.5%	3.69	4.89
1%	4.29	5.61

ARDL: Autoregressive distributed lag

Table 6: Results of short and long run estimates of ARDL model (dependent variable: CO_2)

Model	Coefficient	T-statistics	P-values
Short run estimates			
ΔENI	−0.592	−2.414	0.027
ΔGDP	−0.019	−0.159	0.875
ΔIND	0.023	0.228	0.822
ECT(−1)	−0.705	−4.098	0.001
Long run estimates			
Constant	−2.463	−1.423	0.172
ENI	−0.839	−3.445	0.003
GDP	0.311	2.139	0.046
IND	0.032	0.227	0.823

ARDL model (1, 0, 1, 0); R^2=0.981; Adj. R^2=0.975; F-Stats=181.635; Prob. (F-Stats)=0.000; DW=2.071; Normality test: Jarque-Bera test=1.145; Hetero. Test=1.399. ARDL: Autoregressive distributed lag

Table 7: Results of residual diagnostic test of the model

Joint test	F-Stats	P-value	Decision
Heteroskedaticity	1.399	0.242	No ARCH
Serial correlation	0.028	0.959	No serial correction
Ramsey RESET test	3.141	0.049	No misspecifications
Jarque-Bera test	1.145	0.564	Normally distributed

Serial correlation test using Breusch-Godfrey serial correlation LM test

Figure 4: Results of impulse response function (combined graph). Response of INCO2 to Cholesky One S.D. innovation

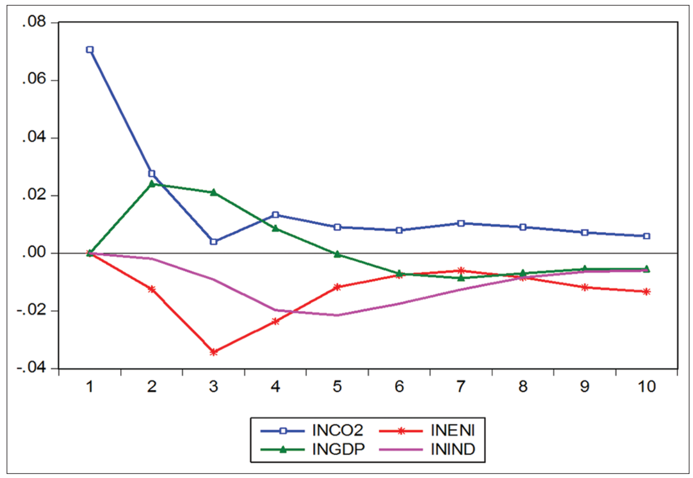


Table 8: Granger-causality test

Null hypothesis	F-statistic	Prob.
INENI does not granger cause INCO2	6.65159	0.0069**
INCO2 does not granger cause INENI	2.30391	0.1286
INGDP does not granger cause INCO2	4.49473	0.0261**
INCO2 does not granger cause INGDP	2.73326	0.0919
ININD does not granger cause INCO2	1.01776	0.3813
INCO2 does not granger cause ININD	0.60587	0.5564
INGDP does not granger cause INENI	2.21925	0.1376
INENI does not granger cause INGDP	2.11836	0.1492
ININD does not granger cause INENI	0.24568	0.7848
INENI does not granger cause ININD	1.17844	0.3304
ININD does not granger cause INGDP	0.51010	0.6089
INGDP does not granger cause ININD	0.62884	0.5445

Table 9: Innovation accounting based on Cholesky's technique

Cholesky ordering: INCO2 INENI INGDP ININD					
Variance decomposition of InCO2					
Period	S.E	INCO2	INENI	INGDP	ININD
1	0.0706	100.0000	0.0000	0.0000	0.0000
2	0.0805	88.6687	2.4046	8.8681	0.0585
3	0.0905	70.3027	16.2205	12.4116	1.0651
4	0.0969	63.2048	20.1048	11.5991	5.0912
5	0.1004	59.7307	20.1170	10.8146	9.3375
6	0.1028	57.6154	19.7552	10.8001	11.8292
7	0.1046	56.6068	19.4086	11.1157	12.8687
8	0.1059	55.9605	19.5718	11.2762	13.1913
9	0.1071	55.1248	20.3449	11.2865	13.2436
10	0.1084	54.1099	21.3725	11.2836	13.2339

decrease emissions by 1.9% in short-run. That is, 1% increase in energy intensity and GDP tend to affect emissions positively in the short-run. However, 1% increase in industrialization in short-run will cause an increase of 2.3% in carbon emissions. In the long-run, both economic growth and industrialization increase of 1% each will cause an increase in carbon emission by 31.1% and 3.2% respectively. On other hand, 1% increase in energy intensity cause a reduction in carbon emission by 83.9% in the long run. However, both in the short and long term, industrialization leads to an increase in carbon dioxide emissions, which reduces the quality of air, health and environment. The Granger causality test showed that ENI and GDP are significant explanatory variables that cause CO_2 emissions in Uganda.

In terms of Policy Implications for Uganda, findings from the analysis through the use of innovative accounting approach in Table 9 depicts that in the short period (i.e., 3) about 70.3% of carbon emissions are caused by its own standard innovation shock. However, one standard deviation change imputed in economic expansion, energy intensity and industrialization will cause carbon dioxide emissions of 12.41%, 16.22% and 1.07% respectively. However, in the long term (i.e., period 10), 54.11% of emissions are caused by its own shock whiles carbon dioxide reacts when a one standard deviation change is imputed in energy intensity, economic growth and industrialization by 21.37%, 11.28% and 13.23% respectively. Findings based on innovative accounting approach using variance decomposition indicates that increase in economic growth in Uganda would lead to an increase in carbon dioxide emissions as 1% increase in economic development would give rise to 10.8% in carbon dioxide (periods 1–6). Beyond this period, that is, from year 2020 going it is expected that Ugandans increase in economic growth would help to reduce the negative impact or improve environment. In the pursuit of carbon emissions mitigation in Uganda, there is the need to increase energy intensity to reduce emissions level in both short and long-run. It is important for Ugandans to balance its GDP growth and environmental sustainable measures.

6. ACKNOWLEDGMENTS

This work was supported by the Korean National Research Foundation Grant, funded by the Korean Government (NRF-2014SIA2027622) and supported in part by the National Science Foundation of China under grants 71471076, 71171099, 71373818 and 71201071 and by the Joint Research of the NSFC-NRF Scientific Cooperation Program under grant 71411170250 and by the Research Fund for the Doctoral Program of Higher Education under grant 20123227110011. This work was also sponsored by the Qing Lan Project of Jiangsu Province, and Jiangsu University Top Talents and Training Project.

REFERENCES

Alam, M.J., Begum I.A., Buysse J., Rahman S.,Van Huylenbroeck, G. (2011), Dynamic modeling of causal relationship between energy consumption, CO2 emissions and economic growth in India. Renewable and Sustainable Energy Reviews, 15(6), 3243-3251.

Alam, M.J., Begum, I.A., Buysse, J. and Van Huylenbroeck, G. (2012), Energy consumption, carbon emissions and economic growth nexus in Bangladesh: Cointegration and dynamic causality analysis. Energy Policy, 45, 217-225.

Ang, J.B. (2007), CO_2 emissions, energy consumption, and output in France. Energy Policy 35(10), 4772-4778.

Appiah, K., Du, J., Musah, A.A.I., Afriyie, S. (2017), Investigation of the relationship between economic growth and carbon dioxide (CO_2) emissions as economic structure changes: Evidence from Ghana. Resources and Environment, 7(6), 160-167.

Arouri, M.E.H., Youssef, A.B., M'henni, H., Rault, C. (2012), Energy consumption, economic growth and CO_2 emissions in Middle East and North African countries. Energy Policy, 45, 342-349.

Ashraf, Z., Javid, A.Y., Javid, M. (2013), Electricity consumption and economic growth: Evidence from Pakistan. Economics and Business Letters, 2(1), 21-32.

Aslan, A. (2014), Causality between electricity consumption and economic growth in Turkey: An ARDL bounds testing approach. Energy Sources, Part B: Economics, Planning, and Policy, 9(1), 25-31.

Asumadu-Sarkodie, S., Owusu, P.A. (2016), Carbon dioxide emission, electricity consumption, industrialization, and economic growth nexus: The Beninese case. Energy Sources, Part B: Economics, Planning, and Policy, 11(11), 1089-1096.

Asumadu-Sarkodie, S., Owusu, P.A. (2017), The causal effect of carbon dioxide emissions, electricity consumption, economic growth, and industrialization in Sierra Leone. Energy Sources, Part B: Economics, Planning, and Policy, 12(1), 32-39.

Aye, G.C., Edoja, P.E. (2017). Effect of economic growth on CO_2 emission in developing countries: Evidence from a dynamic panel threshold model. Cogent Economics and Finance, 5(1), 1379239.

Bank, W. (2017), Available from: http://www.data.worldbank.org.

Bilgili, F., Koçak, E., Bulut, U., Kuloğlu, A. (2017), The impact of urbanization on energy intensity: Panel data evidence considering cross-sectional dependence and heterogeneity. Energy, 133, 242-256.

Charfeddine, L., Khediri, K.B. (2016), Financial development and environmental quality in UAE: Cointegration with structural breaks. Renewable and Sustainable Energy Reviews, 55, 1322-1335.

Elliott, R.J., Sun, P., Zhu, T. (2017), The direct and indirect effect of urbanization on energy intensity: A province-level study for China. Energy, 123, 677-692.

Environment and Water Ministry (2015), Water and Environment Sector Performance Report. Available from: http://www.mwe.go.ug.

Ertugrul, H.M., Cetin,M., Seker, F. and Dogan, E. (2016), The impact of trade openness on global carbon dioxide emissions: Evidence from the top ten emitters among developing countries. Ecological Indicators, 67, 543-555.

Esso, L.J. (2010), Threshold cointegration and causality relationship between energy use and growth in seven African countries. Energy Economics, 32(6), 1383-1391.

Friedlingstein, P., Houghton, R., Marland, G., Hackler, J., Boden, T.A., Conway, T., Canadell, J., Raupach, M., Ciais, P., Le Quere, C. (2010), Update on CO_2 emissions. Nature Geoscience, 3(12), 811.

Ghosh, S. (2010), Examining carbon emissions economic growth nexus for India: A multivariate cointegration approach. Energy Policy, 38(6), 3008-3014.

Hatzigeorgiou, E., Polatidis, H., Haralambopoulos, D. (2011), CO_2 emissions, GDP and energy intensity: A multivariate cointegration and causality analysis for Greece, 1977–2007. Applied Energy, 88(4), 1377-1385.

Huang, Y.K., Hsu, J.Y., Sun, L.C. (2017), A study of energy efficiency and mitigation of carbon emission: Implication of decomposing energy intensity of manufacturing sector in Taiwan. International Journal of Energy Economics and Policy, 7(2), 26-33.

International Energy Agency (IEA). (2017), Key World Energy Statistics. Available from: http://www.iea.org.

Lim, K.M., Lim, S.Y., Yoo, S.H. (2014), Oil consumption, CO_2 emission, and economic growth: Evidence from the Philippines. Sustainability, 6(2), 967-979.

Lin, B., Omoju, O.E., Nwakeze, N.M., Okonkwo, J.U., Megbowon, E.T. (2016), Is the environmental Kuznets curve hypothesis a sound basis for environmental policy in Africa? Journal of Cleaner Production, 133, 712-724.

Lin, B., Omoju, O.E., Okonkwo, J.U. (2015), Impact of industrialisation on CO_2 emissions in Nigeria. Renewable and Sustainable Energy Reviews, 52, 1228-1239.

Liu, L.C., Wu, G., Wang, J.N., Wei, Y.M. (2011), China's carbon emissions from urban and rural households during 1992–2007. Journal of Cleaner Production, 19(15), 1754-1762.

Mensah, J.T. (2014), Carbon emissions, energy consumption and output: A threshold analysis on the causal dynamics in emerging African economies. Energy Policy, 70, 172-182.

Michieka, N.M., Fletcher, J., Burnett, W. (2013), An empirical analysis of the role of China's exports on CO_2 emissions. Applied Energy, 104, 258-267.

Narayan, P.K., Narayan, S. (2010), Carbon dioxide emissions and economic growth: Panel data evidence from developing countries. Energy Policy, 38(1), 661-666.

Onakoya, A.B., Onakoya, A.O., Jimi-Salami, O.A., Odedairo, B.O. (2013), Energy consumption and Nigerian economic growth: An empirical analysis. European Scientific Journal, 9(4). 239-245.

Ozturk, I., Acaravci, A. (2010), CO_2 emissions, energy consumption and economic growth in Turkey. Renewable and Sustainable Energy Reviews, 14(9), 3220-3225.

Raheem, I.D., Ogebe, J.O. (2017), CO_2 emissions, urbanization and industrialization: Evidence from a direct and indirect heterogeneous panel analysis. Management of Environmental Quality: An International Journal, 28(6), 851-867.

Sadorsky, P. (2014), The effect of urbanization on CO_2 emissions in emerging economies. Energy Economics, 41, 147-153.

Sarkodie, S.A., Owusu, P.A. (2017), The relationship between carbon dioxide, crop and food production index in Ghana: By estimating the long-run elasticities and variance decomposition. Environmental Engineering Research, 22(2), 193-202.

Sekantsi, L.P., Okot, N. (2016), Electricity consumption–economic growth nexus in Uganda. Energy Sources, Part B: Economics, Planning, and Policy, 11(12), 1144-1149.

Setiartiti, L. (2018). Renewable energy utilizing for clean energy development. International Journal of Energy Economics and Policy, 8(1), 212-219.

Tang, C.F., Tan, B.W. (2015), The impact of energy consumption, income and foreign direct investment on carbon dioxide emissions in Vietnam. Energy, 79, 447-454.

US Energy Information Administration (EIA). (2015), Independent Statistics and Analysis. Available from: http://www.eia.gov.

Wang, Z., Yin, F., Zhang, Y., Zhang, X. (2012), An empirical research on the influencing factors of regional CO_2 emissions: Evidence from Beijing city, China. Applied Energy, 100, 277-284.

APPENDIX

Appendix A: Root characteristics polynomial

Root	Modulus
0.960755−0.038079i	0.961509
0.960755+0.038079i	0.961509
0.491193−0.545820i	0.734296
0.491193+0.545820i	0.734296
−0.267995−0.462625i	0.534643
−0.267995+0.462625i	0.534643
0.402220	0.402220
−0.271412	0.271412

No root lies outside the unit circle. VAR satisfies the stability condition