International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2016, 6(3), 477-494.

A Causal Relationship between Energy Consumption, Energy Prices and Economic Growth in Africa

Farzana Sharmin[1], Mohammed Robayet Khan[2,3]*

[1]Sub-regional Office for Eastern Africa, United Nations Economic Commission for Africa, Kigali, Rwanda, [2]Office of the Upazila Nirbahi Officer, Shajahanpur Upazila, Government of the People's Republic of Bangladesh, Bogra, Bangladesh, [3]University of Queensland, St. Lucia QLD 4072, Australia. *Email: farzana15859@yahoo.com

ABSTRACT

This paper examines the causal relationships between energy consumption, income and energy prices for the African countries using Johansen's maximum-likelihood test of cointegration and error-correction model (ECM). To have a reliable estimate, only countries having data availability for a minimum period of 25 years were considered. This requirement reduces the sample size to 26 countries only. Out of these, a long run cointegrating relationship was found for a total of six countries, which was then subsequently analyzed to confer on the direction of causality. Out of the reported five countries, we found the existence of bidirectional Granger causality for Ethiopia, Morocco and Mozambique. The result for Angola suggests unidirectional Granger causality running from income to energy consumption while no Granger causality for the case of Tanzania. Findings suggest that countries regardless of their level of income and development should direct their energy conservation policies on the basis of the energy-output causality relation.

Keywords: Energy, Johansen's Maximum Likelihood Test of Cointegration, Error-correction Model
JEL Classifications: C22, Q43, Q48

1. INTRODUCTION

Africa has been growing impressively over the past two decades with the overall improvement in the macroeconomic environment. The robust performance of the economy brings the issue of energy security in the forefront. The continent though is contributing negligibly in global warming, is most severely affected by the climate change. Following the recent ramp up importance on climate change for ensuring sustainable development, energy conservation has become a national priority worldwide. African countries are no exception to this. Therefore, energy conservation has to be considered as one of the policy options at the country level for ensuring long term development. However, different countries are likely to be affected differently by this policy depending on the energy-growth nexus. For instance, if there is a bidirectional Granger causality running between income and energy, it would imply that both the variables affect each other. Therefore, an energy conservation policy, only targeting at an overall reduction in energy consumption, will not be the appropriate one as it would adversely affect the growth. A balance between the two is required in these circumstances. Similarly, a unidirectional Granger causality running from energy to income will imply that reduction in energy consumption could be achieved at the expense of economic growth. When the two are not related, energy conservation policy will have no impact on the economic growth of that particular country. It, thus, warrants a clear understanding of the relationship between energy and economic growth for an effective policy development.

In this study, an attempt is made to analyse the energy-growth relationship in the context of the African countries. Following Engel-Granger (Granger and Newbold, 1974, Engle and Granger 1981) causality methodology, Johansen's multivariate maximum likelihood procedure (Johansen 1988, Johansen and Jesulies (1990) was employed to confer on the direction of causality. Like Lee and Lee (2010) and Costantini and Martini (2010), this paper makes use of the energy prices directly from the World Bank Commodity prices outlook instead of proxying it with consumer price index previously used by a number of economists (Masih and Masih (1998) Asafu-Adjaye (2000) Fatai et al. (2004), Mahadevan and Asafu-Adjaye (2007). The paper also adds value to the existing literature by analysing the energy-growth relationship for the whole continent depending on data availability.

The remainder of the paper is outlined in six sections. After the introductory session, section two analyses a brief overview of the countries covered in the analysis. Section three then discusses existing knowledge on the energy-growth relationship. Next section deals with the empirical model. Section five then analyses the result and finally, section six concludes with some policy recommendations.

2. ECONOMIES WITH HUGE DIFFERENCE

To make reliable estimate, we consider countries having data for a minimum of at least 25 years. It effectively reduced the sample size to only 26 African countries. The resulting sample contains countries with different income levels (such as high, middle and low income countries); each having varying sectorial composition and contribution to gross domestic product (GDP). For instance, some countries have already achieved high level of industrialization while the process is still at its elementary stage for some others. Manufacturing as a percentage of GDP can vary from as high as 18.7% for DRC to as low as 2.4% for Gabon. Population growth rate also differs significantly with some exhibiting very high growth while others having a modest one. Pattern of energy consumption also differs notably with some revealing very high consumption while the rest showing rather modest energy consumption. Despite having different level of income, pace of industrialization or development in general, the decision of energy conservation should be directed by the relationship between energy-growth nexus.

3. LITERATURE REVIEW

Energy-output relationship has created a wide spread academic interest. The empirical literature suggests mixed, and in cases, conflicting relationships between the two. The literature can be categorized on the basis of the four different types of energy-output relationship (Apergis and Payne, 2009, Abbasian et al. 2010, Belke et al. 2011, Fulei, 2010, Ozturk et al., 2010). The direction of relationship hypothesis includes growth, conservation, feedback and neutrality.

The growth hypothesis postulates that energy is an essential component of growth. Therefore, a decrease in energy consumption will lead to a decline in economic growth rate. In this case, the particular country is called to be "energy dependent." Here, the growth hypothesis is confirmed by a unidirectional Granger causality running from energy consumption to economic growth. Studies suggesting this hypothesis includes Yu and Choi (1985), Tsani (2010), Stern (1993, 2000), Lee and Chang (2008), Apergis and Payne (2009), Yang and Zhao (2014) Ang (2007), Ho and Siu (2007), Warr and Ayres (2010), Hossain and Saeki (2011), Pirlogea and Cicea (2012), Lee (2005), Narayan and Smyth (2007), Zamani (2007), Wolde-Rufael (2004) and others.

The conservation hypothesis suggests that energy conservation policies will have no impact on economic growth, and thus, the countries with this scenario can go for an energy conservation policy without any adverse effect on growth. The hypothesis applies when there is a unidirectional Granger causality running from GDP to energy. The relevant literature of this hypothesis are: Kraft and Kraft (1978), Ghosh (2002), Abosedra and Baghestani (1991), Al-Iriani (2006), Lise and Montfort (2007), Mehrara (2007a and b), Zhang and Cheng (2009), Bartleet and Gounder (2010), Souhila and Kourbali (2012), Ocal and Aslan (2013), Herrerias et al. (2013), Cheng and Lai (1997), Cheng (1999), Aqeel and Butt (2001), Oh and Lee (2004b), Hatzigeorgiou et al. (2011), Hossain (2011), Farhani and Rejeb (2012), Ang (2008), and Yang (2000a).

The feedback hypothesis states that energy consumption and economic growth are interdependent and affect each other. A bidirectional causality between energy consumption and GDP substantiates feedback hypothesis. Hwang and Gum (1992), Zarnikau (1997), Glasure and Lee (1995, 1996), Zarnikau (1997), Lee (2006), Jumbe (2004), Lee and Chang (2005), Francis et al. (2007), Erdal et al. (2008), Belloumi (2009), Zhang (2011), Eggoh et al. (2011) Belke et al. (2011), Abid and Sebri (2011), Sadorsky (2012), Zhang and Xu (2012), Masih and Masih (1998), Glasure (2002), Hondroyiannis et al. (2002), Ghali and El-Sakka (2004), Oh and Lee (2004a), Climent and Pardo (2007), Yuan et al. (2008), Apergis and Payne (2010), Pao and Tsai (2011), Wang et al. (2011), Shahbaz et al. (2012), Al-Mulali and Che Sab (2012), Saboori and Sulaiman (2013a) found feedback relationship between these two.

The neutrality hypothesis asserts that energy does not affect economic growth and vice versa. An absence of Granger causality between energy consumption and GDP is supportive of the neutrality hypothesis. Studies which found neutral relation between energy and growth include: Akraca and Long (1980), Yu and Jin (1992), Fatai et al. (2002), Altinay and Karagol (2004), Bowden and Payne (2009), Yu and Hwang (1984), Cheng (1996), Soytas and Sari (2006a), Jobert and Karanfil (2007), Soytas et al. (2007), Soytas and Sari (2008), Payne (2009), Ozturk and Acaravci (2010), Alam et al. (2011), Abalaba and Dada (2013) and so on.

There is a voluminous literature of mixed relationship between the two. Studies which include more than one country often suggest mixed relationship between the two variables (Table 1). There are instances of conflicting findings on the same country too. The most cited example is the seminal work of Kraft and Kraft (1978) and Akarca and Long (1980). Employing Sims methodology, Kraft and Kraft (1978) found a unidirectional causality running from energy consumption to GNP in USA for the period 1947-1974. Unlike their findings, Akarca and Long (1980) found no evidence of causality between these two variables by shortening the study period by just 2 years. The main reason for these conflicting findings are primarily attributed to the methodological differences, country specific heterogeneity, different study periods, and in cases, dissimilar definitions of the variables concerned (Masih and Masih 1997, Belke et al. 2011). Appendix Table 1 summarizes the

Table 1: Countries having different level of development

Country	Total population (millions)	Population growth rate	GDP in billions at constant 2005 USD	Manufacturing as a % of GDP	Manufacturing export as a % of total merchandise export	Energy use (kg of oil equivalent per capita)
Algeria	38.9	1.9	132.4		3.4	1237.3
Angola	24.2	3.3	61.1	7.1		629.6
Benin	15.7	2.6	6.3	8.1	2.3	389.6
Botswana	2.2	2.0	15.8	6.0	189.9	1014.5
Cameroon	22.8	2.5	23.3	14.1	10.5	322.5
Congo republic	4.5	2.5	9.3	4.7	21.1	399.8
Cote d'Ivoire	22.2	2.4	24.0		15.8	597.4
Democratic republic of Congo	74.9	3.2	21.2	17.8		292.4
Egypt	89.6	2.2	131.4	16.4	51.5	913.1
Ethiopia	97.0	2.5	30.5	4.2	8.8	493.5
Gabon	1.7	2.2	12.3	2.4		1371.1
Ghana	26.8	2.4	20.5	6.2	11.3	396.6
Kenya	44.9	2.6	29.6	11.1		482.8
Mauritius	1.3	0.2	9.0	16.5	62.5	1067.8
Morocco	33.9	1.4	87.1	15.3	65.4	569.9
Mozambique	27.2	2.8	11.9		16.5	405.6
Nigeria	177.5	2.7	194.9	9.8	2.9	794.9
Senegal	14.7	3.1	11.8	13.5	34.5	299.5
South Africa	54.0	1.6	328.7	13.3	49.6	2674.8
Sudan	39.4	2.1	38.3	8.4		342.1
Syria	22.2	1.7	na		na	701.2
Togo	7.1	2.7	3.1	5.7	56.8	463.0
Tunisia	11.0	1.0	Na	na	71.3	918.0
Tanzania	51.8	3.2	29.6	6.1	25.2	455.6
Zambia	15.7	3.1	16.2		11.7	614.0
Zimbabwe	15.2	2.3	6.9	11.9	27.0	657.7

Source: WDI[1]: World development ındicators, GDP: Gross domestic product

available literature on the energy-growth nexus in both bivariate and multivariate frame works[2].

4. DATA AND THE EMPIRICAL MODEL

The paper analyses long run cointegrating relationship among GDP, energy use and energy prices for the African countries. GDP is represented as "*y*" and is proxied by GDP at constant local currency from World development ındicators (WDI) data set. Energy consumption is energy use kilogram of oil equivalent per capita from WDI data set and is represented by "*en*." Finally energy price is extracted from energy price index of WEO dataset and is represented by "*p*."

After performing the augmented Dickey-Fuller (ADF) and Phillips-Perron tests of stationarity (Dickey and Fuller, 1981, Phillips and Perron, 1988), the error-correction model (ECM) were estimated following Asafu-Adjaye (2000):

$$Dy_t = A_{11}(L)Dy_{t-1}+A_{12}(L)Den_{t-1}+A_{13}Dp_{t-1}+\lambda_y ECT_{t-1}+u_{1t} \quad (1)$$

$$Den_t = A_{21}(L)Dy_{t-1}+A_{22}(L)Den_{t-1}+A_{23}(L)Dp_{t-1}+\lambda_{en} ECT_{t-1}+u_{2t} \quad (2)$$

$$Dp_t = A_{31}(L)Dy_{t-1}+A_{32}(L)Den_{t-1}+A_{33}(L)Dp_{t-1}+\lambda_p ECT_{t-1}+u_{3t} \quad (3)$$

Where y_t, en_t and p_t are GDP at constant local currency, energy consumption per kg of oil equivalent per capita and energy prices respectively; D is the difference operator; A_{ij}(L) are the polynomials in the lag operator L; error-correction terms (ECT) is the lagged ECT derived from the long run cointegrating relationship and the u_{its} are the ECT assumed to be uncorrelated and random with mean zero. The coefficients, λ_i (i=*en, y, p*) of the ECTs represent the deviation of the dependent variables from the long run equilibrium, i.e. ECT.

If the variables y_t, en_t and p_t are cointegrated then it can be expected that at least one or all of the ECTs should be significantly non-zero. Direction of Granger causality are measured here by testing:

1. A t-test of the λ_i;
2. Wald test for the joint significance of the sum of the lags of each of the explanatory variables; and,
3. A joint Wald test of the interactive terms of ECT and each independent variables in the particular equation, i.e. (λ_y and A_{12}) and (λ_y and A_{13}) in equation (1); (λ_{en} and A_{21}) and (λ_{en} and A_{23}) in equation (2) and (λ_p and A_{31}) and (λ_p and A_{32}) in equation (3).

The most cited limitation of using time series data is the estimate being less reliable for low number of observation. Considering this problem, a number of studies used panel cointegration technique to show cointegrating relationship among the variables. One notable feature of the data set used in these studies is that it did not necessarily analyze within country features as the cross sectional

1 All the data are in 2014 except for energy use which corresponds to 2012 for data availability problem. For Ethiopia, Ghana, Nigeria, Morocco, Republic of Congo, Democratic Republic of Congo, Tanzania, Togo and Tunisia manufacturing as a % of merchandise export value are for 2012.

2 To have a more detailed analysis of the existing literature please see Belke et al (2010) and Isa et al. (2015).

property of the panel data. The data set used in these studies mostly contain time series properties as it shows change of values of a variable overtime. Therefore, this paper intended to show the growth-energy nexus for all African countries using time series analysis. To overcome the problem of reliability, countries having a dataset of at least 25 years are considered which ultimately shortened the sample size down to 26 countries.

Johansen's maximum likelihood test for multiple cointegration was then employed to the sample. In this paper, instead of (VAR), vector error correction model (VECM) is used to have information on both long and short run relationship. Since in VAR model, variables are considered in the first difference form, it removes long run information (Oh and Lee, 2004a) from the model. Considering this as a next step, cointegration among the variables was tested for each sample countries. We found long run cointegrating relationship among the variables for six countries only. However, in the paper, we reported result for five countries. The model for Ghana did not pass most of the robustness tests. Hence, in order to get a robust estimate, the paper did not include the result for the country. For checking robustness of the estimates, the paper made use of VECM LM test for residual autocorrelation, test for normally distributed disturbances and stability condition of the model.

5. RESULT ANALYSIS

The result for non-stationarity using ADF and PP test are summarized in Table 2. It can be seen that with the exception of energy variable of Mozambique, the null hypothesis of non-stationarity could not be rejected at even 10% level in the level form for all variables in all five countries. However, after taking first differences, the variables become stationary for the most cases. We got identical decisions from both ADF and PP tests for all the cases except energy variable of Mozambique. Here, the variable is stationary after taking first difference according to ADF test while it is stationary at level according to the PP test. Therefore, it can be concluded that the income, energy and price variables are mostly integrated of order one, that is I(1). However, the Table 2 shows that income variable for Angola, Ethiopia, Mozambique and Tanzania as well as energy variable of Ethiopia could be integrated of order two, that is I(2). Since, most of the variables are integrated of order one, i.e., I(1), the paper intended to use Johansen's maximum likelihood test for cointegration.

In the following step, Johansen's multivariate maximum likelihood test for cointegration was applied to look for the possibilities of a long run relationship among the variables. The test results are reported in Table 3. Here r represents the number of the cointegrating vectors. It can be seen that for Angola and Ethiopia, the null hypothesis of no cointegration is rejected against the alternative of one cointegrating relationship at even 1% level. For Morocco and Mozambique, the null hypothesis of no cointegration can be rejected against the alternative of one cointegrating relationship at the 5% level. In the case of Tanzania, the test results suggest two cointegrating relationships among the variables. The result of having long run cointegrating relationship among the variables indicate that there must be Granger causality in at least one direction. Johansen's maximum likelihood tests, however, does not indicate the direction of temporal causality between the variables (Asafu-Adjaye, 2000). In this paper, we apply ECM to confer about the direction of the temporal causality among the variables.

The ECM model provides us with the "short-run" and "long- run" effects of the variables. It shows the direction of causality among the concerned variables. The result of temporal Granger causality is reported in Table 4. Wald F statistic and in case of countries having one lag selected from the information criterion, t statistic were used to confer on the significance of the "short-run" effect of the lagged explanatory variables in the ECM. To indicate the significance of

Table 2: Results of unit root tests

Country/	Augmented Dickey-Fuller (ADF)			Phillips-Perron (PP)		
variable	Level	First difference	Second difference	Level	First difference	Second difference
Angola						
y_t	1.54	−1.39	−4.65***	3.23	−1.39	−4.65***
en_t	1.28	−3.88***	-	1.40	−3.88***	-
p_t	1.79	−6.60***	-	0.90	−6.64***	-
Ethiopia						
y_t	1.60	−1.07	−6.54***	5.82	−1.07	−6.54***
en_t	1.30	−1.13	−7.42***	2.04	−1.13	−7.42***
p_t	0.71	−6.41***	-	0.56	-6.41***	
Morocco						
y_t	5.57	−4.39***	-	12.02	−4.39***	-
en_t	4.60	−3.69***	-	6.67	−3.69***	-
p_t	1.03	−7.10***	-	0.91	−7.10***	-
Mozambique						
y_t	2.80	−0.79	−7.79***	7.98	−0.79	−7.79***
en_t	−1.09	−3.53***	-	−2.92***	-	-
p_t	0.68	−6.52***	-	0.55	−6.52***	-
Tanzania						
y_t	2.81	−0.18	−7.27***	11.36	−0.18	−7.27***
en_t	1.17	−2.22**	-	1.40	−2.22**	-
p_t	1.91	−5.81***	-	1.82	−5.81***	-

The optimal lag for the ADF tests were selected using Akaike Information Criteria (AIC). The unit root test result is reported for variables in level with no drift and trend term, ADF: Augmented Dickey-Fuller, PP: Phillips-Perron the ECT, we used t-statistics. It indicates the long run causal effects. Finally, joint Wald F-statistics for the interactive terms (i.e., the ECTs and each of the lagged explanatory variables) are reported in the right panel of the table. The interactive terms give an indication of which variables have to adjust in the short run to re-establish the long-run equilibrium subject to a shock in the system.

Table 3: Results of Johansen's maximum likelihood tests for multiple cointegrating relationships (intercept, no trend)

Country/null hypothesis	Trace statistics	Eigenvalue statistics	5% critical value	1% critical value
Angola				
Maximum rank				
r=0	68.40		29.68	35.65
r=1	3.57	0.91	15.41	20.04
r=2	0.00	0.12	3.76	6.65
r=3		0.00		
Ethiopia				
r=0	51.22		29.68	35.65
r=1	7.24	0.76	15.41	20.04
r=2	0.00	0.21	3.76	6.65
r=3		0.00		
Morocco				
r=0	33.24		29.68	35.65
r=1	3.56	0.52	15.41	20.04
r=2	0.00	0.09	3.76	6.65
r=3		0.00		
Mozambique				
r=0	32.30		29.68	35.65
r=1	4.25	0.62	15.41	20.04
r=2	0.00	0.14	3.76	6.65
r=3		0.00		
Tanzania				
r=0	65.78		29.68	35.65
r=1	28.47	0.83	15.41	20.04
r=2	0.00	0.74	3.76	6.65
r=3		0.00		

The lag length of the model is determined on the basis of the length suggested by AIC and the maximum information criteria

We reported the Temporal Granger causality results for both short and long run effects in Table 4. It can be seen that, for Angola, the t statistic for the variable energy in income equation is significant at even 1% level. Similarly, income variable in the price equation is statistically significant at 5% level. The short run effect for price variable is not statistically significant in either of the two equations. It implies that for Angola, both energy and income interacts in the short run to restore long run equilibrium. Looking at the statistical significance of the ECT term, we found that the term is statistically significant at 10% level with correct sign for all three equations implying long run causality among all the three variables. From the last three columns, we found the statistical significance of the interactive terms of ECT and each of the lagged explanatory variables. Here, the interactive term of ECT and income are statistically significant for both energy and price equation implying that in the long run income Granger causes energy and price. This finding is thus indicative of an energy conservation hypothesis.

Turning to Ethiopia, we found that the t statistics for energy variable in the price equation is statistically significant at 1% level. None of the other two lagged explanatory variables are statistically significant in either income or energy equations. It suggests that, in the short run, there is a unidirectional Granger causality running from energy consumption to price while income has a neutral effect on both energy and price. The t statistics of the ECT term is statistically significant but with a very low value in the energy equation. The term is statistically significant at 5% level in the price equation with the correct sign. However, for income equation, it does not even have correct sign. The interactive terms of all three variables are statistically significant at different levels. It implies that all three variables adjust in a dynamic fashion to restore long run equilibrium. The result suggests an existence of a feedback hypothesis in the long run.

For Morocco, we found that the short run effect of energy variable in the income equation is statistically significant at 10% level. We

Table 4: Temporal Granger-causality results

Country/ dependent variable	Wald F-statistics/t-statistics			ECT only t-ratio	Wald F-statistics		
	Dy_t	Den_t	Dp_t		Dent*ECT	Dpt, ECT	Dyt, ECT
Angola							
Dy_t	-	−1013832***	−1.03	−0.19*	3.69	3.68	-
Den_t	5.35	-	−0.36	−0.23*	-	3.60	3.04*
Dp_t	1.65e-10**	−0.17	-	−0.67*	3.89	-	3.76*
Ethiopia							
Dy_t	-	−1.19	−1.20	0.17**	11.31***	11.33***	-
Den_t	3.10	-	-0.05	−0.001***	-	11.49***	9.75***
Dp_t	3.48	−3.21***	-	-0.05**	10.18***	-	4.13**
Morocco							
Dy_t	-	4.99*	1.71	0.05***	23.06***	18.78***	-
Den_t	-	-	0.61	−0.51***	-	12.57***	12.05***
Dp_t	0.00	2.76	-	−0.34	4.27	-	0.27
Mozambique							
Dy_t	-	15.49***	1.74	0.11**	23.41***	11.12**	-
Den_t	-	-	15.74***	−0.35**	-	18.11***	6.53***
Dp_t	1.03	1.72	-	−1.53*	4.41	-	8.0
Tanzania							
Dy_t	-	6.73	7.44	−0.03	7.61	8.95	-
Den_t	-	-	0.61	−0.004	-	1.34	0.00
Dp_t	-	5.48	-	−1.37***	15.70***	-	8.96***

ECT: Error-correction terms

did not get any short run effect of income variable for the energy equation. However, there is no statistically significant short run effects of the lagged explanatory variable implying that only energy bears the burden of short run adjustment. Looking at the ECT term, it can be seen that the ECT term for income equation has wrong sign while ECT term for price equation, though has correct sign, is not statistically significant. Only ECT term of the energy equation is statistically significant at 1% level. The Wald F statistics for interactive terms of price equation are also not statistically significant like the short run effects and ECT term. It, thus, implies that the variable is possibly exogenous to the system. The interactive terms of income and energy equations are statistically significant at different levels. Like Ethiopia, it also indicates a possibility of a feedback relation between the variables.

The case of Mozambique is similar to the case of Morocco for short run effects. Here also, we did not get short run effects of income variable in the energy equation. From the Table 4, it can be seen that short run effects of energy variable in income equation and price variables in energy equation are statistically significant. It suggests that in the short run both energy and price adjust to the long run equilibrium. For income equation, ECT term has wrong sign but the term is statistically significant with correct sign at 5% and 10% level for energy and price equation respectively. Looking at the interactive terms, it can be found that Like Morocco, the terms are statistically significant at different levels for both the variables in income and energy equation. Therefore, the result for Mozambique is also suggestive of a feedback hypothesis.

For Tanzania, none of the lagged explanatory variables is statistically significant in any of the three equations in the short run. The ECT term has the right sign for all three equations but it is statistically significant only for price equation. Interactive terms in the price equation are statistically significant at 1% level for both variables. None of the interactive terms for other two equations is statistically significant. The result for Tanzania is thus indicative of a neutrality hypothesis.

The result further indicates that countries can have very different level of income, different size of population, stage of industrialization and energy use (Table 1) but similar energy-growth relationship (example includes Ethiopia, Morocco and Mozambique). Despite difference in the level of economic development, a common energy policy could be developed and implemented for these countries on the basis of the energy-growth nexus. Therefore, a country with a low level of income might need to pursue a policy similar to a high income countries. Likewise, countries with comparable level of income might have to follow different energy policies depending on their energy-economic growth dynamics.

The model showed reasonable goodness-of-fit based on F and R^2 statistics and passed most of the diagnostic tests mentioned earlier.

6. CONCLUSION

The ECM results show that the countries though have a long run cointegrating relationship among all three variables, exhibit differing direction of causality. One notable feature is that three (Ethiopia, Morocco and Mozambique) out of these five countries have feedback relationship, which implies limited space for pursuing energy conservation directly. Therefore, countries need to focus on technological development for cleaner and more efficient energy mix to ensure sustained green growth. A balanced combination of alternative policies targeted at increasing energy efficiency as well as energy intensity can be an option. The countries may opt for an energy transition having higher share of renewable energy in the total energy mix of the country. Therefore, finding the right energy policy at the national level on the basis of the energy-growth relationship is needed. The Energy conservation hypothesis for Angola suggests that the country can pursue an energy conservation policy with no adverse impact on economic growth. The result is thus supportive of the finding of Chontanawat et al. (2006) and Hossein et al. (2012) where they got similar relationship for another oil depending country Saudi Arabia. For Tanzania, we found neutrality hypothesis having no Granger causality running between the variables, which is surprising given the large natural gas reserve the country endows. One plausible explanation for these findings could be that the country has still not tapped into the resource to its fullest potential. Hence, the resource still does not have adequate impact on the economic growth. The non-existence of the causality could be stemmed out of this low utilization and resulting weaker energy-growth relationship. In this paper, we have shown cointegrating relation following a VECM approach, which significantly reduced the sample size. As a further research, the long run cointegrating relationship for all the other countries of the continent can be looked at employing an unrestricted VAR model.

REFERENCES

Abbasian, E., Nazari, M., Nasrindost, M. (2010), Energy consumption and economic growth in the Iranian economy: Testing the causality relationship. Middle-East Journal of Scientific Research, 5(5), 374-381.

Abalaba, B.P., Dada, M.A. (2013), Energy consumption and economic growth nexus: New empirical evidence from Nigeria. International Journal of Energy Economics and Policy, 3(4), 412-423.

Abid, M., Sebri, M. (2011), Energy consumption-economic growth nexus: Does the level of aggregation matter? International Journal of Energy Economics and Policy, 2(2), 55-62.

Abosedra, S., Baghestani, H. (1991), New evidence on the causal relationship between United States energy consumption and gross national product. Journal of Energy and Development, 14, 285-292.

Acaravci, A., Ozturk, I. (2010), On the relationship between energy consumption, CO2 emissions and economic growth in Europe. Energy, 35(12), 5412-5420.

Akarca, A.T., Long, T.V. (1980), On the relationship between energy and GNP: A reexamination. Journal of Energy Development, 5, 326-331.

Akinlo, A.E. (2008), Energy consumption and economic growth: Evidence from 11 Sub-Sahara African countries. Energy Economics, 30, 2391-2400.

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.

Al-Iriani, M.A. (2006), Energy-GDP relationship revisited: An example from GCC countries using panel causality. Energy Policy, 34,

3342-3350.
Alkhathlan, K., Javid, M. (2013), Energy consumption, carbon emissions and economic growth in Saudi Arabia: An aggregate and disaggregate analysis. Energy Policy, 62, 1525-1532.
Al-Mulali, U., Che Sab, C.N. (2012), The impact of energy consumption and CO2 emission on the economic growth and financial development in the Sub Saharan African countries. Energy, 39(1), 180-186.
Altinay, G., Karagol, E. (2004), Structural break, unit root, and the causality between energy consumption and GDP in Turkey. Energy Economics, 26, 985-994.
Ang, J.B. (2007), CO2 emissions, energy consumption, and output in France. Energy Policy, 35, 4772-4778.
Ang, J.B. (2008), Economic development, pollutant emissions and energy consumption in Malaysia. Journal of Policy Modeling, 30, 271-278.
Apergis, N., Payne, J.E. (2009), Energy consumption and economic growth in Central America: Evidence from a panel co-integration and error correction model. Energy Economics, 31, 211-216.
Apergis, N., Payne, J.E. (2010), Renewable energy consumption and economic growth: Evidence from a panel of OECD countries. Energy Policy, 38, 656-660.
Aqeel, A., Butt, S. (2001), The relationship between energy consumption and economic growth in Pakistan. Asia Pacific Development Journal, 8, 101-110.
Asafu-Adjaye, J. (2000), The relationship between energy consumption, energy prices, and economic growth: Time series evidence from Asian developing countries. Energy Economics, 22, 615-625.
Bartleet, M., Gounder, R. (2010), Energy consumption and economic growth in New Zealand: Results of trivariate and multivariate models. Energy Policy, 38(7), 3508-3517.
Belke, A., Dobnik, F., Dreger, C. (2011), Energy consumption and economic growth: New insights into the co-integration relationship. Energy Economic, 33(5), 782-789.
Belloumi, M. (2009), Energy consumption and GDP in Tunisia: Co-integration and causality analysis. Energy Policy, 37(7), 2745-2753.
Bowden, N., Payne, J.E. (2009), The causal relationship between US energy consumption and real output: A disaggregated analysis. Journal of Policy Modeling, 31(2), 180-188.
Cheng, B.S. (1996), An investigation of co-integration and causality between energy consumption and economic growth. Journal of Energy and Development, 21, 73-84.
Cheng, B.S. (1997), Energy consumption and economic growth in Brazil, Mexico and Venezuela: A time series analysis. Applied Economics Letters, 4, 671-774.
Cheng, B.S. (1998), Energy consumption, employment and causality in Japan: A multivariate approach. Indian Economic Review, 33(1), 19-29.
Cheng, B.S. (1999), Causality between energy consumption and economic growth in India: An application of co-integration and error correction modeling. Indian Economic Review, 34(1), 39-49.
Cheng, B.S., Lai, T.W. (1997), An investigation of co-integration and causality between energy consumption and economic activity in Taiwan. Energy Economics, 19(4), 435-444.
Chiou-Wei, S.Z., Chen, C.F., Zhu, Z. (2008), Economic growth and energy consumption: Evidence from linear and nonlinear Granger causality. Energy Economics, 30, 3063-3076.
Chontanawat, J., Hunt, L.C., Pierse, R. (2006), Causality between Energy Consumption and GDP: Evidence from 30 OECD and 78 non-OECD Countries. Surrey Energy Economics Discussion Paper Series 113. Guildford: University of Survey.
Climent, F., Pardo, A. (2007), Decoupling factors on the energy-output linkage: The Spanish case. Energy Policy, 35, 522-528.
Costantini, V., Martini, C. (2010), The causality between energy consumption and economic growth: A multi-sectoral analysis using non-stationary co-integrated panel data. Energy Economic, 32(3), 591-603.
Dergiades, T., Martinopoulos, G., Tsoulfidis, L. (2013), Energy consumption and economic growth: Parametric and non-parametric causality testing for the case of Greece. Energy Economics, 36, 686-697.
Dickey, D.A., Fuller, W.A. (1981), Likelihood ratio statistics for autoregressive time series with a unit root. Econometrica, 49, 1057-1072
Ebohon, O.J. (1996), Energy, economic growth and causality in developing countries: A case study of Tanzania and Nigeria. Energy Policy, 24, 447-453.
Eggoh, J.C., Bangake, C., Rault, C. (2011), Energy consumption and economic growth revisited in African countries. Energy Policy, 39(11), 7408-7421.
Engle, R.E., Granger, C.W.J. (1981), Co-integration and error-correction: Representation, estimation and testing. Econometrica, 55, 251-276.
Erdal, G., Erdal, H., Eseng ̈ un, K. (2008), The causality between energy consumption and economic growth in Turkey. Energy Policy, 36(10), 3838-3842.
Erol, U., Yu, E.S.H. (1987a), On the causal relationship between energy and income for industrialized countries. Journal of Energy and Development, 13, 113-122.
Farhani, S., Rejeb, J.B. (2012), Energy consumption, economic growth and CO2 emissions: Evidence from panel data for MENA region. International Journal of Energy Economics and Policy, 2(2), 71-81.
Fatai, K., Oxley, L., Scrimgeour, F. (2002), Energy Consumption and Employment in New Zealand: Searching for Causality. NZAE Conference, Wellington. 26-28 June, 2002.
Fatai, K., Oxley, L., Scrimgeour, F.G. (2004), Modelling the causal relationship between energy consumption and GDP in New Zealand, Australia, India, Indonesia, the Philippines, and Thailand. Mathematics and Computers in Simulation, 64, 431-445.
Francis, B.M., Moseley, L., Iyare, S.O. (2007), Energy consumption and projected growth in selected Caribbean countries. Energy Economics, 29, 1224-1232.
Fuinhas, J.A., Marques, A.C. (2012), Energy consumption and economic growth nexus in Portugal, Italy, Greece, Spain and Turkey: An ARDL bounds test approach (1965–2009). Energy Economic, 34(2), 511-517.
Fulei, W. (2010), A Summary on the Relationship between Economic Growth and Energy Consumption. e-Business and Information System Security (EBISS) 2nd International Conference, 22-23 May. p1-4.
Ghali, K.H., El-Sakka, M.I.T. (2004), Energy and output growth in Canada: A multivariate co-integration analysis. Energy Economics, 26, 225-238.
Ghosh, S. (2002), Electricity consumption and economic growth in India. Energy Policy, 30, 125-129.
Glasure, Y.U. (2002), Energy and national income in Korea: Further evidence on the role of omitted variables. Energy Economics, 24, 355-365.
Glasure, Y.U., Lee, A.R. (1998), Co-integration, error correction, and the relationship between GDP and energy: The case of South Korea and Singapore. Resource and Energy Economics, 20, 17-25.
Granger, C.W.J., Newbold, P. (1974), Spurious regreassions in econometrics. Journal of Econometrics, 2, 111-120.
Hatzigeorgiou, E., Politakis, H., Haralambopoulos, D. (2011), CO2 emissions, GDP and energy intensity: A multivariate co-integration and causality analysis for Greece, 1977–2007. Applied Energy, 88(4), 1377-1385.
Herrerias, M.J., Joyeux, R., Girardin, E. (2013), Short-and long-run causality between energy consumption and economic growth:

Evidence across regions in China. Applied Energy, 112, 1483-1492.
Ho, CY., Siu, K.W. (2007), A dynamic equilibrium of electricity consumption and GDP in Hong Kong: An empirical investigation. Energy Policy, 35(4), 2507-2513.
Hondroyiannis, G., Lolos, S., Papapetrou, E. (2002), Energy consumption and economic growth: Assessing the evidence from Greece. Energy Economics, 24, 319-336.
Hossain, M.D.S., Saeki, C. (2011), Does electricity consumption panel granger cause economic growth in South Asia? Evidence from Bangladesh, India, Iran, Nepal, Pakistan and Sri-Lanka. European Journal of Social Sciences, 25(3), 316-328.
Hossain, M.S. (2011), Panel estimation for CO2 emissions, energy consumption, economic growth, trade openness and urbanization of newly industrialized countries. Energy Policy, 39(11), 6991-6999.
Hossein, S.S.M., Yazdan, G.F., Hasan, S. (2012), Consideration the relationship between energy consumption and economic growth in oil exporting country. Procedia-Social and Behavioral Sciences, 62, 52-58.
Huang, B.N., Hwang, M.J., Yang, C.W. (2008), Causal relationship between energy consumption and GDP growth revisited: A dynamic panel data approach. Ecological Economics, 67, 41-54.
Hwang, D., Gum, B. (1992), The causal relationship between energy and GNP: The case of Taiwan. Journal of Energy and Development, 12, 219-226.
Isa, Z., Al Sayed, A.R.M., Kun, S.S. (2015), Review paper on economic growth-aggregate energy consumption nexus. International Journal of Energy Economics and Policy, 2015,5(2),385-401.
Jobert, T., Karanfil, F. (2007), Sectoral energy consumption by source and economic growth in Turkey. Energy Policy, 35, 5447-5456.
Johansen, S. (1988), Statistical analysis of co-integrating vectors. Journal of Economic Dynamic Control, 12, 231-254.
Johansen, S., Juselius, K. (1990), Maximum likelihood estimation and inferences on co-integration with approach. Oxford Bulletin of Economics and Statistics, 52, 169-209.
Jumbe, C.B.L. (2004), Co-integration and causality between electricity consumption and GDP: Empirical evidence from Malawi. Energy Economics, 26, 61-68.
Kraft, J., Kraft, A. (1978), On the relationship between energy and GNP. Journal of Energy and Development, 3, 401-403.
Lau, E., Chye, X.H., Choong, C.K. (2011), Energy-growth causality: Asian countries revisited. International Journal of Energy Economics and Policy, 1(4), 140-149.
Lee, C.C. (2005), Energy consumption and GDP in developing countries: A co-integrated panel analysis. Energy Economics, 27, 415-427.
Lee, C.C. (2006), The causality relationship between energy consumption and GDP in G-11 countries revisited. Energy Policy, 34(9), 1086-1093.
Lee, C.C., Chang, C.P. (2005), Structural breaks, energy consumption, and economic growth revisited: Evidence from Taiwan. Energy Economics, 27, 857-872.
Lee, C.C., Chang, C.P. (2008), Energy consumption and economic growth in Asian economies: A more comprehensive analysis using panel data. Resource and Energy Economics, 30, 50-65.
Lee, C., Lee, J. (2010), A panel data analysis of the demand for total energy and electricity in OECD countries. Energy Journal, 31(1), 1-23.
Lise, W., Montfort, K.V. (2007), Energy consumption and GDP in Turkey: Is there a co-integration relationship? Energy Economics, 29, 1166-1178.
Mahadevan, R., Asafu-Adjaye, J. (2007), Energy consumption, economic growth and prices: A reassessment using panel VECM for developed and developing countries. Energy Policy, 35, 2481-2490.
Masih, A.M.M., Masih, R. (1996), Energy consumption, real income and temporal causality: Results from a multi-country study based on co-integration and error-correction modeling techniques. Energy Economics, 18, 165-183.
Masih, A.M.M., Masih, R. (1997), On temporal causal relationship between energy consumption, real income, and prices: Some new evidence from Asian-energy dependent NICs based on a multivariate co-integration/vector error correction approach. Journal of Policy Modeling, 19, 417-440.
Masih, A.M.M., Masih, R. (1998), A multivariate co-integrated modeling approach in testing temporal causality between energy consumption, real income, and prices with an application to two Asian LDCs. Applied Economics, 30, 1287-1298.
Mehrara, M. (2007a), Energy consumption and economic growth: The case of oil exporting countries. Energy Policy, 35, 2939-2945.
Mehrara, M. (2007b), Energy-GDP relationship for oil-exporting countries: Iran, Kuwait, and Saudi Arabia. OPEC Review, 31, 1-16.
Nachane, D.M., Nadkarni, R.M., Karnik, A.V. (1988), Co-integration and causality testing of the energy-GDP relationship: A cross-country study. Applied Economics, 20, 1511-1531.
Narayan, P.K., Popp, S. (2012), The energy consumption-real GDP nexus revisited: Empirical evidence from 93 countries. Economic Modeling, 29(2), 303-308.
Narayan, P.K., Smyth, R. (2007), Energy consumption and real GDP in G7 countries: New evidence from panel co-integration with structural breaks. Energy Economics, 30, 2331-2341.
Ocal, O., Aslan, A. (2013), Renewable energy consumption–economic growth nexus in Turkey. Renewable and Sustainable Energy Reviews, 28, 494-499.
Odhiambo, N.M. (2010), Energy consumption, prices and economic growth in three SSA countries: A comparative study. Energy Policy, 38(5), 2463-2469.
Oh, W., Lee, K. (2004a), Causal relationship between energy consumption and GDP revisited: The case of Korea 1970-1999. Energy Economics, 26, 51-59.
Oh, W., Lee, K. (2004b), Energy consumption and economic growth in Korea: Testing the causality relation. Journal of Policy Modeling, 26, 973-981.
Ozturk, I., Acaravci, A. (2010), CO2 emissions, energy consumption and economic growth in Turkey. Renewable and Sustainable Energy Reviews, 14(9), 3220-3225.
Ozturk, I., Acaravci, A. (2010), The causal relationship between energy consumption and GDP in Albania, Bulgaria, Hungary and Romania: Evidence from ARDL bound testing approach. Applied Energy, 87(6), 1938-1943.
Ozturk, I., Aslan, A., Kalyoncu, H. (2010), Energy consumption and economic growth relationship: Evidence from panel data for low and middle income countries. Energy Policy, 38(8), 4422-4428.
Pao, H.T., Tsai, C.M. (2011), Multivariate granger causality between CO2 emissions, energy consumption, FDI and GDP: Evidence from a panel of BRIC (Brazil, Russian Federation, India and China) countries. Energy, 36(1), 685-693.
Paul, S., Bhattacharya, R.N. (2004), Causality between energy consumption and economic growth in India: A note on conflicting results. Energy Economics, 26, 977-983.
Payne, J.E. (2009), On the dynamics of energy consumption and output in the US. Applied Energy, 86(4), 575-577.
Phillips, P.C.B., Perron, P. (1988), Testing for a unit root. Biometrica 75, 335-346.
Pirlogea, C., Cicea, C. (2012), Econometric perspective of the energy consumption and economic growth relation in European Union. Renewable and Sustainable Energy Reviews, 16(8), 5718-5726.
Saboori, B., Sulaiman, J. (2013a), Environmental degradation, economic growth and energy consumption: Evidence of the environmental Kuznets curve in Malaysia. Energy Policy, 60, 892-905.
Saboori, B., Sulaiman, J. (2013b), CO2 emissions, energy consumption and economic growth in Association of Southeast Asian Nations (ASEAN) countries: A co-integration approach. Energy, 55, 813-822.

Sadorsky, P. (2012), Energy consumption output and trade in South America. Energy Economic, 34(2), 476-488.

Shahbaz, M., Zeshan, M., Afza, T. (2012), Is energy consumption effective to spur economic growth in Pakistan? New evidence from bounds test to level relationships and Granger causality tests. Economic Modeling, 29(6), 2310-2319.

Shahiduzzaman, M., Alam, K. (2012), Co-integration and causal relationships between energy consumption and output: Assessing the evidence from Australia. Energy Economic, 34(6), 2182-2188.

Shiu, A., Lam, P.L. (2004), Electricity consumption and economic growth in China. Energy Policy, 32, 47-54.

Souhila, C., Kourbali, B. (2012), Energy consumption and economic growth in Algeria: Co-integration and causality analysis. International Journal of Energy Economics and Policy, 2(4), 238-249.

Soytas, U., Sarı, R., Ozdemir, O. (2001), Energy consumption and GDP relation in Turkey: A co-integration and vector error correction analysis. In: Economies and Business in Transition: Facilitating Competitiveness and Change in the Global Environment Proceedings. Global Business and Technology Association. p838-844. Available from: http://www.sari_r2.web.ibu.edu.tr/yayinlarim/Ener gy%20Soytas_Sari_Ozdemir.pdfS. [Last accessed on 2014 Dec 24].

Soytas, U., Sari, R. (2003), Energy consumption and GDP: Causality relationship in G-7 and emerging markets. Energy Economics, 25, 33-37.

Soytas, U., Sari, R. (2006a), Can China contribute more to the fight against global warming? Journal of Policy Modeling, 28, 837-846.

Soytas, U., Sari, R. (2006b), Energy consumption and income in G7 countries. Journal of Policy Modeling, 28, 739-750.

Soytas, U., Sari, R. (2008), Energy consumption, economic growth, and carbon emissions: Challenges faced by an EU candidate member. Ecological Economics, 68(6), 1667-1675.

Soytas, U., Sari, R., Ewing, B.T. (2007), Energy consumption, income, and carbon emissions in the United States. Ecological Economics, 62, 482-489.

Stern, D.I. (1993), Energy and economic growth in the USA: A multivariate approach. Energy Economics, 15, 137-150.

Stern, D.I. (2000), A multivariate co-integration analysis of the role of energy in the US macroeconomy. Energy Economics, 22, 267-283.

Tsani, S.Z. (2010), Energy consumption and economic growth, a causality analysis for Greece. Energy Economic, 32(3), 582-590.

Wang, S., Zhou, D., Zhou, P., Wang, Q. (2011), CO2 emissions, energy consumption and economic growth in China: A panel data analysis. Energy Policy, 39(9), 4870-4875.

Warr, B.S., Ayres, R.U. (2010), Evidence of causality between the quantity and quality of energy consumption and economic growth. Energy, 35(4), 1688-1693.

Wesseh, P.K.Jr., Zoumara, B. (2012), Causal independence between energy consumption and economic growth in Liberia: Evidence from a non-parametric bootstrapped causality test. Energy Policy, 50, 518-527.

Wolde-Rufael, Y. (2004), Disaggregated industrial energy consumption and GDP: The case of Shanghai, 1952 1999. Energy Economics, 26, 69-75.

Wolde-Rufael, Y. (2005), Energy demand and economic growth: The African experience. Journal of Policy Modeling, 27, 891-903.

Yang, H.Y. (2000a), A note on the causal relationship between energy and GDP in Taiwan. Energy Economics, 22, 309-317.

Yang, Z., Zhao, Y. (2014), Energy consumption, carbon emissions, and economic growth in India: Evidence from directed acyclic graphs. Economic Modeling, 38, 533-540.

Yu, E.S.H., Choi, J.Y. (1985), The causal relationship between energy and GNP: An international comparison. Journal of Energy and Development, 10, 249-272.

Yu, E.S.H., Hwang, B. (1984), The relationship between energy and GNP: Further results. Energy Economics, 6, 186-190.

Yu, E.S.H., Jin, J.C. (1992), Co-integration tests of energy consumption, income, and employment. Resources and Energy, 14, 259-266.

Yuan, J., Kang, J., Zhao, C., Hu, Z. (2008), Energy consumption and economic growth: Evidence from China at both aggregated and disaggregated levels. Energy Economics, 30, 3077-3094.

Zachariadis, T. (2007), Exploring the relationship between energy use and economic growth with bivariate models: New evidence from G-7 countries. Energy Economics, 29, 1233-1253.

Zamani, M. (2007), Energy consumption and economic activities in Iran. Energy Economics, 29, 1135-1140.

Zarnikau, J. (1997), A reexamination of the causal relationship between energy consumption and gross national product. Journal of Energy and Development, 21, 229-239.

Zhang, C.R., Xu, J. (2012), Retesting the causality between energy consumption and GDP in China: Evidence from sectoral and regional analyses using dynamic panel data. Energy Economics, 34(6), 1782-1789.

Zhang, X.P., Cheng, X.M. (2009), Energy consumption, carbon emissions, and economic growth in China. Ecological Economics, 68(10), 2706-2712.

Zhang, Y.J. (2011), Interpreting the dynamic nexus between energy consumption and economic growth: Empirical evidence from Russia. Energy Policy, 39(5), 2265-2272.

APPENDIX

Author	Methodology	Study period	Scope	Results
Akarca and Long (1980)	Sims causality	1950-1970	USA	GNP-EC
Abosedra and Baghestani (1991)	Granger causality	1947-1987	USA	GNP→EC
Altinay and Karagol (2004)	Granger causality	1950-2000	Turkey	GDP-EC
Al-Iriani (2006)	Pedroni panel cointegration	1971-2002	Panel of 6 middle East countries	GDP→EC
Ang (2007)	Cointegration, VECM	1960-2000	France	EC→GDP
Ang (2008)	JJ and VECM	1971-1999	Malaysia	GDP→EC
Akinlo (2008)	ARDL	1980-2003	Gambia	GDP→EC
			Ghana	GDP→EC
			Sudan	GDP→EC
			Zimbabwe	GDP→EC
			Congo	GDP→EC
Abid and Sebri (2011)	VECM	1980-2007	Tunisia	GDP↔EC
Asafu-Adjaye (2000)	JJ	1973-1995	India	EC→GDP
		1973-1995	Indonesia	EC→GDP
		1971-1995	Thailand	EC↔GDP
		1971-1995	Philippines	EC↔GDP
Aqeel and Butt (2001)	EG	1955-1996	Pakistan	GDP→EC
Apergis and Payne (2009)	Pedroni panel cointegtration	1980-2004	Panel of six South American countries	EC→GDP
Acaravci and Ozturk (2010)	Cointegration ARDL	1960-2005	Austria	EC-GDP
			Belgium	EC-GDP
			Denmark	EC-GDP
			Finland	EC-GDP
			France	EC-GDP
			Germany	EC-GDP
			Greece	GDP→EC
			Hungary	EC-GDP
			Iceland	EC-GDP
			Ireland	GDP→EC
			Italy	EC-GDP
			Luxembourge	EC-GDP
			Netherlands	EC-GDP
			Norway	EC-GDP
			Portugal	EC-GDP
			Spain	EC-GDP
			Sweden	EC-GDP
			Switzerland	EC↔GDP
			UK	EC-GDP
Apergis and Payne (2010)	Cointegration and ECM	1985-2005	20 OECD countries	EC↔GDP
Alam et al (2011)	VECM Dynamic modelling	1971-2006	India	EC-GDP
Al-mulali and Che Sab (2012)	Panel cointegration, panel causality	1980-2008	Panel of 30 Sub-Saharan countries	EC↔GDP
Abalaba and Dada (2013)	ECM and JJ	1971-2010	Nigeria	EC-GDP
Alkhathlan and Javid (2013)	ARDL, VECM	1980-2011	Saudi Arabia	EC-GDP
Belloumi (2009)	Granger causality and VECM	1971-2004	Tunisia	GDP↔EC
Bowden and Payne (2009)	TY	1949-2006	USA	GDP-EC
Bartleet and Gounder (2010)	ARDL cointegration, ECM causality	1960-2004	New Zealand	GDP→EC
Belke et al (2011)	Dynamic Panel Causality	1981-2007	Panel of 25 OECD	GDP↔EC
Chontanawat et al (2006)	JJ and dynamic panel estimation	1960-2000	OECD countries	

(*Contd...*)

Author	Methodology	Study period	Scope	Results
			Australia	GDP→EC
			Austria	EC→GDP
			Belgium	EC→GDP
			Canada	GDP→ EC
			Czech	EC→GDP
			Denmark	EC→GDP
			Finland	GDP→EC
			France	GDP↔EC
			Germany	GDP↔EC
			Greece	GDP↔EC
			Hungary	GDP↔EC
			Iceland	GDP↔EC
			Ireland	C→GDP
			Italy	GDP↔EC
			Japan	GDP↔EC
			Korea	EC→GDP
			Luxembourge	GDP-EC
			Mexico	EC→GDP
			The Netherlands	EC→GDP
			New Zealand	GDP↔EC
			Norway	GDP↔EC
			Poland	EC→GDP
			Portugal	GDP↔EC
			Slovakia	GDP↔EC
			Spain	GDP→EC
			Sweden	GDP→EC
			Switzerland	EC→GDP
			Turkey	GDP-EC
			UK	GDP-EC
			USA	GDP-EC
		1971-2000	Non-OECD Countries	
			Albania	GDP→EC
			Algeria	GDP→EC
			Angola	GDP↔EC
			Argentina	GDP↔EC
			Bahrain	GDP-EC
			Bangladesh	EC→GDP
			Benin	GDP-EC
			Bolivia	GDP→EC
			Brazil	GDP↔EC
			Brunei	GDP↔EC
			Bulgaria	GDP→EC
			Cameroon	GDP-EC
			Chile	EC→GDP
			China	GDP-EC
			Colombia	EC→GDP
			Congo	GDP-EC
			Congo Republic	EC→GDP
			Costa Rica	GDP→EC
			Cote d’Ivoire	GDP-EC
			Cuba	GDP→EC
			Cyprus	EC→GDP
			Dominican Republic	EC→GDP
			Ecuador	GDP-EC
			Egypt	EC→GDP
			El Salvador	GDP→EC
			Ethiopia	GDP→EC
			Gabon	GDP-EC
			Ghana	GDP↔EC
			Gibraltar	GDP↔EC
			Haiti	GDP-EC

(*Contd...*)

Author	Methodology	Study period	Scope	Results
			Honduras	GDP-EC
			Hong Kong	GDP-EC
			India	GDP-EC
			Iran	GDP↔EC
			Iraq	GDP-EC
			Israel	EC→GDP
			Jamaica	GDP-EC
			Jordan	GDP↔EC
			Kenya	EC→GDP
			Kuwait	GDP↔EC
			Lebanon	GDP↔EC
			Libya	GDP-EC
			Malaysia	GDP-EC
			Malta	GDP-EC
			Morocco	GDP↔EC
			Mozambique	GDP↔EC
			Myanmar	GDP↔EC
			Nepal	EC→GDP
			Nicaragua	GDP-EC
			Nigeria	GDP-EC
			Oman	EC→GDP
			Pakistan	GDP-EC
			Panama	GDP→EC
			Paraguay	GDP→EC
			Peru	GDP→EC
			Philippines	EC→GDP
			Qatar	GDP↔EC
			Romania	GDP↔EC
			Saudi Arabia	GDP→EC
			Senegal	GDP-EC
			Singapore	GDP-EC
			Sri Lanka	GDP-EC
			Sudan	GDP↔EC
			Taiwan	GDP↔EC
			Tanzania	GDP-EC
			Thailand	GDP→EC
			Togo	GDP-EC
			Trinidad	GDP↔EC
			Tunisia	GDP↔EC
			UAE	GDP↔EC
			Uruguay	EC→GDP
			Venezuela	GDP→EC
			Vietnam	EC→GDP
			Yemen	GDP↔EC
			Zambia	GDP-EC
			Zimbabwe	GDP→EC
Chiou et al (2008)	JJ; Baek and Brock	1954-2006	Taiwan	EC→GDP
	non-linear Granger	1971-2003	Hong Kong	EC→GDP
	causality	1971-2003	Singapore	GDP→EC
		1971-2003	Korea	GDP-EC
		1971-2003	Malaysia	GDP-EC
		1971-2003	Indonesia	GDP↔EC
		1971-2003	Philippines	GDP→EC
		1960-2003	Thailand	GDP-EC
			USA	GDP-EC
Cheng (1996)	EG	1947-1990	USA	EC-GNP
Cheng (1997)	EG	1963-1993	Brazil	EC→GDP
		1949-1993	Mexico	EC-GDP
		1952-1993	Venezuela	EC-GDP
Cheng and Lai (1997)	EG	1955-1993	Taiwan	GDP→EC
				EC→EMP

(*Contd...*)

Author	Methodology	Study period	Scope	Results
Cheng (1998)	JJ and Hsiao's methodology	1952-1995	Japan	GNP→EC
Cheng (1999)	JJ, cointegration, ECM and Granger causality	1952-1995	India	GNP→EC
Climent and Pardo (2007)	JJ	1984-2003	Spain	EC↔GDP
Costantini and Martini (2010)	VECM	1960-2005	71 countries	GDP→EC
			26 OECD	EC↔GDP
			45 non-OCED	GDP→EC
Dergiades et al (2013)	Parametric and non-parametric test	1960-2008	Greece	EC→GDP
Erol and Yu (1987a)	Sims and Granger causality	1950-1982	Japan	EC↔GNP
		1950-1982	Germany	GNP→EC
		1950-1982	Italy	GNP→EC
		1950-1980	Canada	EC→GNP
		1950-1982	France	GNP-EC
			UK	GNP-EC
Ebohon (1996)	Granger causality	1960-1981	Tanzania	GDP↔EC
		1960-1984	Nigeria	GDP↔EC
Erdal et al. (2008)	Pair-wise Granger causality and JJ	1970-2006	Turkey	GDP↔EC
Eggoh et al. (2011)	Panel cointegration, Panel causality	1970-2006	African 21 countries	GDP↔EC
			Energy exporters 11	GDP↔EC
			Energy importers 10	GDP↔EC
Fatai et al. (2002)	Granger causality, ARDL and TY	1960-1999	New Zealand	GDP-EC
Fatai et al. (2004)	Granger-Causality, TY, ARDL and JJ	1960-1999	Australia	GDP→EC
			New Zealand	GDP→EC
			India	EC→GDP
			Indonesia	EC→GDP
			Thailand	EC↔GDP
			Philippines	EC↔GDP
Francis et al. (2007)	EG	1971-2002	Haiti	GDP↔EC
			Jamaica	GDP↔EC
			Trinidad and Tobago	GDP↔EC
Fuinhas and Marques (2012)	ARDL cointegration and ECM	1965-2009	Portugal	GDP↔EC
			Italy	GDP↔EC
			Greece	GDP↔EC
			Spain	GDP↔EC
			Turkey	GDP↔EC
Farhani and Ben (2012)	Panel cointegration, panel causality	1973-2008	15 MENA countries	GDP→EC
Glasure and Lee (1998)	EG	1961-1990	South Korea	GDP↔EC
			Singapore	GDP↔EC
Ghosh (2002)	Cointegration	1950-1997	India	GDP→EC
Glasure (2002)	JJ and VDC	1961-1990	Korea	EC↔GDP
Ghali and El-Sakka (2004)	JJ, VDC and VEC	1961-1997	Canada	EC↔GDP
Hwang and Gum (1992)	Granger causality	1961-1990	Taiwan	GNP↔EC
Ho and Siu (2007)	Cointegration, VECM	1966-2002	Hong Kong	EC→GDP
Hossain and Saeki (2011)	Panel causality (Granger EG and GMM)	1971-2007	Panel of South Asian countries	EC→GDP
Herrerias et al. (2013)	Panel cointegration techniques	1995-2009	China	GDP→EC
Hondroyiannis et al. (2002)	JJ and VECM	1960-1999	Greece	EC↔GDP

(Contd...)

Author	Methodology	Study period	Scope	Results
Huang et al. (2008)	Dynamic panel estimation, GMM and VAR	1972-2002	Low income	EC-GDP
			Middle income	GDP→EC
			High income	GDP→EC
			Overall	EC↔GDP
Hatzigeorgiou et al. (2011)	Cointegration, JJ and VECM	1977-2007	Greece	GDP→EC
Hossain (2011)	Granger causality and EG	1971-2007	Panel of 9 NIC	GDP→EC
Hossein et al. (2012)	EG and ECM	1980-2008	Iran	GDP→EC
			Iraq	GDP→EC
			Qatar	GDP→EC
			UAE	GDP→EC
			Saudi Arabia	GDP→EC
			Algeria	EC→GDP
Jumbe (2004)	Cointegration	1970-1999	Malawi	GDP↔EC
Jobert and Karanfil (2007)	JJ	1960-2003	Turkey	EC-GNP EC-IVA
Kraft and Kraft (1978)	Granger and Sims causality	1947-1974	USA	GDP→EC
Lee and Chang (2005)	JJ	1954-2003	Taiwan	EC↔GDP
Lee (2006)	TY	1960-2001	Belgium	EC→GDP
		1965-2001	Canada	EC→GDP
		1960-2001	France	GDP→EC
		1971-2001	Germany	GDP-EC
		1960-2001	Italy	GDP→EC
		1960-2001	Japan	GDP→EC
		1960-2001	The Netherlands	EC→GDP
		1960-2001	Sweden	GDP-EC
		1960-2001	Switzerland	EC→GDP
		1960-2001	UK	GDP-EC
		1960-2001	USA	GDP↔EC
Lise and Montfort (2007)	EG	1970-2003	Turkey	GDP→EC
Lau et al. (2011)	Granger causality test and FMOLS	1980-2006	Panel of 17 Asian countries	GDP→EC
Lee (2005)	Pedroni panel cointegration	1975-2001	Panel of 18 developing countries	EC→GDP
Lee and Chang (2008)	Pedroni panel cointegration	1971-2002	Asian panel	EC→GDP
			APEC	EC→GDP
			ASEAN	EC→GDP
Mashi and Masih (1996)	JJand VDC	1955-1990	India	GNP→EC
		1955-1990	Pakistan	GNP↔EC
		1960-1990	Indonesia	GNP→EC
		1955-1990	Malaysia	GNP-EC
		1960-1990	Singapore	GNP-EC
		1955-1991	Philippines	GNP-EC
Mehrara (2007a)	Pedroni panel cointegration	1971-2002	Panel of 7 countries in the middle east	GDP→EC
Mehrara (2007b)	TY and JJ	1971-2002	Iran	GDP→CEC
			Kuwait	GDP→CEC
			Saudi Arabia	CEC→GDP
Masih and Masih (1997)	JJ, VDC and IRF	1961-1990	Korea	GDP↔EC
			Taiwan	GDP↔EC
Masih and Masih (1998)	JJ, VDC and IRF	1955-1991	Thailand	EC→GDP
			Sri Lanka	EC→GDP

(*Contd...*)

Author	Methodology	Study period	Scope	Results
Mahadevan and Asafu-Adjaye (2007)	Pedroni panel cointegration, JJ and VECM	1971-2002	Exporters developed	EC↔GDP
			Australia	EC↔GDP
			Norway	EC↔GDP
			UK	EC↔GDP
			Exporters developing	EC↔GDP
			Argentina	EC↔GDP
			Indonesia	EC↔GDP
			Kuwait	EC↔GDP
			Malaysia	EC↔GDP
			Nigeria	EC↔GDP
			Saudi Arabia	EC↔GDP
			Venezuela	EC↔GDP
			Importers developed	EC↔GDP
			Japan	EC↔GDP
			Sweden	EC↔GDP
			USA	EC↔GDP
			Importers developing	EC→GDP
			Ghana	EC↔GDP
			India	EC→GDP
			Senegal	EC→GDP
			South Africa	EC↔GDP
			South Korea	EC→GDP
			Singapore	EC↔GDP
			Thailand	EC→GDP
Nachane et al. (1988)	EG	1950-1985	Argentina	CEC→GDP
			Brazil	CEC↔GDP
			Chile	CEC→GDP
			Colombia	CEC↔GDP
			Greece	CEC→GDP
			Guatemala	CEC→GDP
			India	CEC↔GDP
			Israel	CEC↔GDP
			Portugal	CEC→GDP
			Mexico	CEC→GDP
			Venezuela	CEC↔GDP
			France	CEC→GDP
			Germany	CEC↔GDP
			Italy	CEC→GDP
			Japan	CEC↔GDP
			UK	CEC→GDP
Narayan and Popp (2012)	Panel cointegration, panel causality	1980-2006	Global panel 93	GDP↔EC
			Western European 20	EC→GDP
			Asian panel 17	EC→GDP
			Latin American 17	EC→GDP
			Middle East 12	GDP-EC
			African panel 25	GDP↔EC
			G6 panel 6	EC→GDP
Narayan and Smyth (2007)	Pedroni panel cointegration	1972-2002	Panel of 7 western countries	EC→GDP
Ozturk et al.(2010)	Pedroni panel cointegration	1971-2005	51 countries	
			Low income 14	GDP→EC
			Lower middle 24	GDP↔EC
			Upper middle 13	GDP↔EC
Ocal and Aslan (2013)	ARDL and TY	1990-2010	Turkey	GDP→REC
Oh and Lee (2004a)	JJ, Granger causality and VECM	1970-1999	Korea	EC↔GDP

(*Contd...*)

Author	Methodology	Study period	Scope	Results
Oh and Lee (2004b)	JJ	1981-2000	South Korea	EC↔GDP
Odhiambo (2010)	Cointegration	1972-2006	South Africa	EC→GDP
	ARDL and ECM		Kenya	EC→GDP
			Congo	GDP→EC
Ozturk and Acaravci (2010)	Cointegration, ARDL	1968-2005	Turkey	EC-GDP
Ozturk and Acaravci (2010)	ARDL and ECM	1980-2006	Albania	GDP-EC
			Bulgaria	GDP-EC
			Hungary	GDP↔EC
			Romania	GDP-EC
Payne (2009)	TY	1949-2006	USA	EC-GDP
Pao and Tsai (2011)	Cointegration panel causality	1980-2007	Panel of 4 BRIC countries	EC↔GDP
Pirlogea and Cicea (2012)	Cointegration	1990-2010	Romania	EC→GDP
			Spain	EC→GDP
Paul and Bhattacharya (2004)	EG and JJ	1950-1996	India	EC↔GDP
Soytas et al. (2001)	Cointegration,	1954-1997	Taiwan	EC↔GDP
	Granger causality	1960-1995	Turkey	EC→GDP
Soytas and Sari (2003)	JJ and VDC	1950-1990	Argentina	GDP↔EC
		1950-1992	Canada	GDP-EC
		1950-1992	France	EC →GDP
		1950-1992	Germany	EC→GDP
		1960-1992	Indonesia	GDP-EC
		1953-1991	Italy	GDP→EC
		1950-1992	Japan	EC→GDP
		1953-1991	Korea	GDP→EC
		1965-1994	Poland	GDP-EC
Sadorsky (2012)	Panel cointegration, panel causality	1980-2007	Panel of 7 South American countries	GDP↔EC
Souhila and Kourbali (2012)	Threshold cointegration and Granger causality	1965-2008	Algeria	GDP→EC
Shahiduzzaman and Alam (2012)	JJ, cointegration and VECM	1960-2009	Australia	GDP↔EC
Stern (1993)	Granger causality and VAR	1947-1990	USA	EC→GDP
Stern (2000)	JJ and Granger causality	1948-1994	USA	EC→GDP
Soytas and Sari (2006a)	TY and VDC	1971-2002	China	EC-GDP
Soytas and Sari (2006b)	JJ and VDC	1960-2004	Canada	EC↔GDP
		1970-2002	France	EC→GDP
		1971-2002	Germany	EC↔GDP
		1960-2004	Italy	EC↔GDP
		1960-2004	Japan	EC↔GDP
		1960-2004	UK	EC↔GDP
		1960-2004	USA	EC→GDP
Soytas et al.(2007)	TY and VDC	1960-2000	USA	EC-GDP
Soytas and Sari (2008)	TY and VDC	1960-2000	Turkey	EC-GDP
Shahbaz et al. (2012)	ARDL and VECM	1972-2011	Pakistan	EC↔GDP
				EC↔GDP

(*Contd...*)

Author	Methodology	Study period	Scope	Results
Shiu and Lam (2004)	Cointegration and ECM	1971-2000	China	EC→GDP
Saboori and Sulaiman (2013a)	ARDL and JJ	1980-2009	Malaysia	EC↔GDP
Saboori and Sulaiman (2013b)	ARDL and VECM	1971-2008	Indonesia	EC↔GDP
			Malaysia	EC↔GDP
			Philippines	EC↔GDP
			Singapore	GDP→EC
			Thailand	GDP→EC
Tsani (2010)	TY	1960-2006	Greece	EC→GDP
Wolde-Rufael (2004)	TY	1952-1999	Shanghai	EC→GDP
Wolde-Rufael (2005)	ARDL and TY	1971-2001	Algeria	GDP→EC
			Benin	GDP-EC
			Cameroon	EC→GDP
			DR Congo	GDP→EC
			Rep Congo	GDP-EC
			Egypt	GDP→EC
			Gabon	GDP↔EC
			Ghana	GDP→EC
			Ivory Coast	GDP→EC
			Kenya	GDP-EC
			Morocco	EC→GDP
			Nigeria	EC→GDP
			Senegal	GDP-EC
			South Africa	GDP-EC
			Sudan	GDP-EC
			Togo	GDP-EC
			Tunisia	GDP-EC
			Zambia	GDP↔EC
			Zimbabwe	GDP-EC
Warr and Ayres (2010)	JJ, cointegration, VECM	1946-2000	USA	EC→GDP
Wesseh Jr and Zoumara (2012)	Parametric and non-parametric Granger causality approaches	1980-2008	Liberia	GDP↔EC
Wang et al. (2011)	Panel cointegration, VECM	1995-2007	China	EC↔GDP
Yu and Choi (1985)	Sims and Granger causality	1947-1979	USA	GNP-EC
		1950-1976	UK	EC→GNP
		1950-1976	Poland	GNP-→EC
		1950-1976	Philippines	EC→GNP
		1954-1976	South Korea	GNP→EC
Yu and Jin (1992)	Granger causality	1974-1990	USA	GDP-EC
Yang (2000)	EG	1954-1997	Taiwan	EC↔GDP
Yu and Hwang (1984)	Sims and Granger causality	1947-1979	USA	GNP-EC EC→EMP
Yuan et al. (2008)	JJ and IRF	1963-2005	China	EC↔GDP
Yang and Zhao (2014)	Granger causality and DAG	1979-2008	India	EC→GDP EC→CO_2

(*Contd...*)

Author	Methodology	Study period	Scope	Results
Zarnikau (1997)	Granger causality	1970-1992	USA	GNP↔EC
Zhang and Cheng (2009)	Granger causality	1960-2007	China	GDP→EC
Zhang (2011)	TY and Time-varying cointegration	1970-2008	Russia	GDP↔EC
Zhang and Xu (2012)	Panel cointegration, panel causality	1995-2008	China	GDP↔EC
Zachariadis (2007)	JJ, ARDL and TY	1960-2004	Canada	All: GDP→EC
			France	JJ: EC↔GDP ARDL: GDP→EC TY: EC-GDP
			Germany	JJ: EC↔GDP ARDL: GDP→EC TY: EC-GDP
			Italy	JJ:EC↔GDP ARDL: EC↔GDP TY: EC-GDP
			Japan	JJ: EC↔GDP ARDL:EC↔GDP TY: EC→GDP
			UK	All: GDP→EC
			USA	All EC-GDP
Zamani (2007)	EG	1967-2003	Iran	GDP→EC

GDP: Gross domestic product, VECM: Vector error correction model , ECM: Error-correction model