Oil Consumption in Transport and Economic Growth Nexus: Empirical Evidence from Cameroon

Youssouf Nvuh Njoya, PhD
University of Yaounde II, Cameroon
Mouhamed Mbouandi Njikam, PhD
University of Dschang, Cameroon

Doi:10.19044/esj.2018.v14n10p409 URL:http://dx.doi.org/10.19044/esj.2018.v14n10p409

Abstract

This paper focuses on casting light on the causal relationship between oil consumption in transport and economic growth in Cameroon. This paper uses an annual data covering the period 1975-2014, which is a five-step modern time series techniques. They include the Unit root tests, co-integration analysis, and Granger-causality based on error correction model. As a robustness test, we made use of the impulse response function and variance decomposition to portray the correlations between variables. The main result highlighted in the present paper point out the presence of a long-run equilibrium relationship between oil consumption in transport and economic growth. The error correction model shows that an estimated 1% increase in economic growth causes a rise in oil consumption in transport by 1.29 % in the long run. Another results show that there exists bidirectional causality in the long-run relationship and there was no causality in the short-run relationship at the 5% level of significance. The decomposition of the variance and impulse response function indicates a dissymmetric of the variance of the prediction error and the dynamic properties of the system. This study provides a basis for the discussion of energy consumption in transport policies in order to maintain a sustainable economic growth in Cameroon.

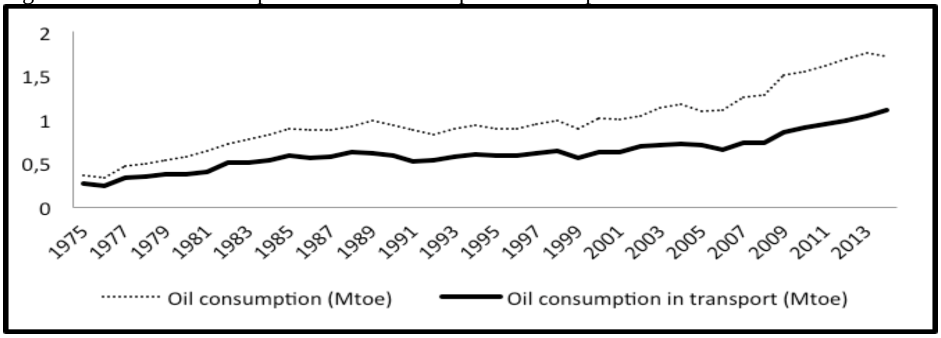
Keywords: Oil consumption in transport, Economic growth, Co-integration, Causality, impulse response function, decomposition of variance

1. Introduction

Energy consumption is the foundation of the modern industrial economy, which greatly contributes to human and economic development. It has been the backbone for almost all economic activities for decades. The crucial role played by energy as a key driver of economic activities is well documented in available literature. Among the determinants of consumption, GDP is the main explanatory factor. Indeed, energy is necessary for the production and consumption of all the goods and services in industry and services. It is also essential in both countries, particularly in African countries, and Cameroon is not an exception.

Observing the evolution of the total oil consumption in Cameroon over the period 1975-2014, transport represents an average of 63% of the total consumption. Therefore, this demonstrates the importance of the transport sector.

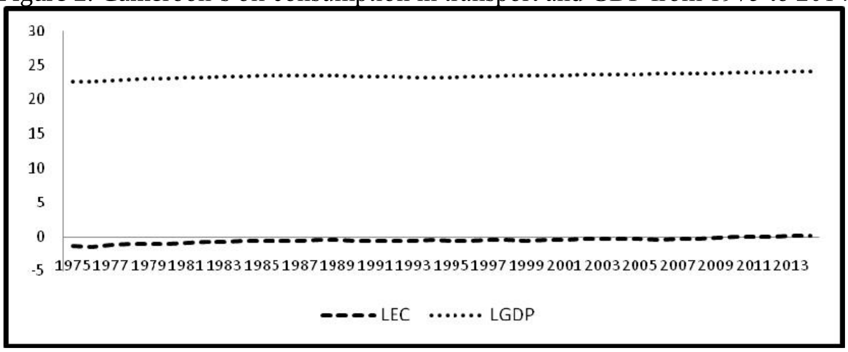
Figure 1. Total oil consumption and oil consumption in transport from 1975 to 2014 in Cameroon



Source: Authors from IEA database

However, the transport sector heavily depends on energy. In the world today, the transportation sector represents 20% of total energy used in 2011 (US Energy Information Administration (EIA), 2015). It is the second sector after the industrial sector in regards to energy consumption. According to the IEA outlook world, energy consumption grows with the global economy. The success of the transport sector is highly dependent upon the level of energy in the economy. In fact, the transport sector can be seen as the largest user of energy in the economy (Reddy et al., 2001; Samimi, 1995). The consumption of energy is likely to grow up further due to economic growth, population growth, rapid industrialization, urbanization, and agricultural modernization (Ramanathan & Parikh, 1999).

Figure 2. Cameroon's oil consumption in transport and GDP from 1975 to 2014

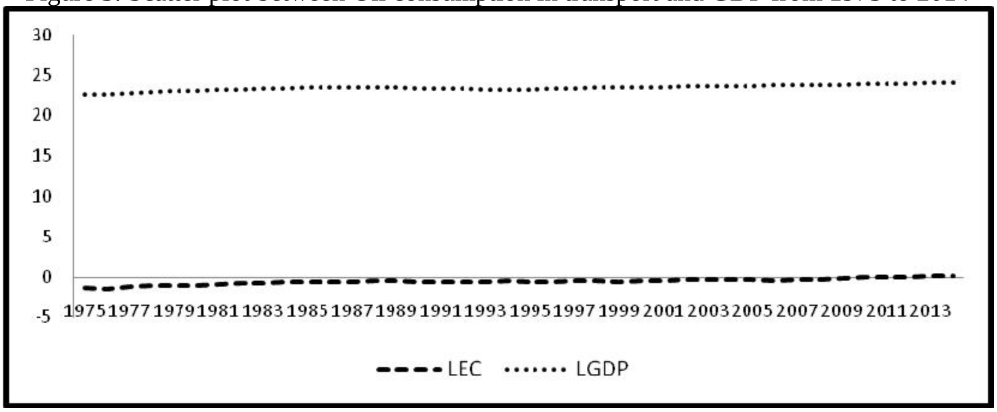


Source: Authors from IEA database and WDI database

Figure 2 above shows the evolution of oil consumption in transport and the economic growth of Cameroon from 1975 to 2014. We can observe that these two variables show similar long-run trends characterized by upward trends, with slopes of 0.0248 for the logarithm of GDP and 0.0271 for the logarithm of oil consumption in transport. Also, there is an equilibrium relationship or plausible co-integration between these two series.

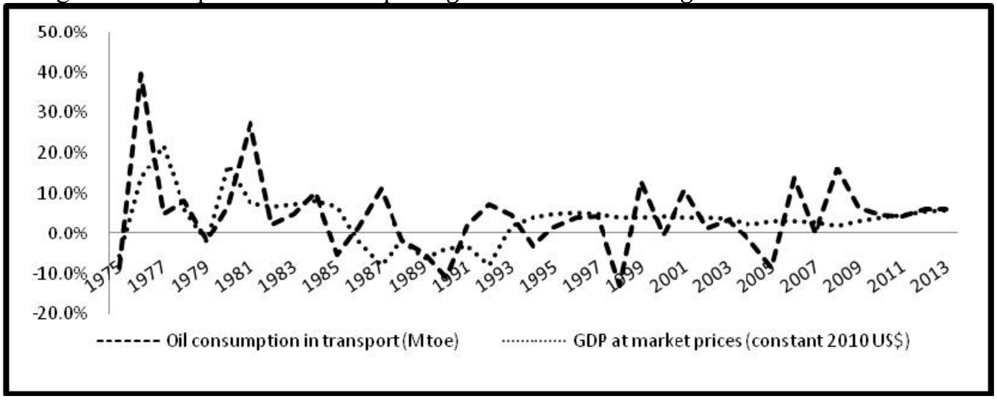
Moreover, statistical analysis confirms a strong positive correlation between oil consumption in transport and GDP (Figure 3). This correlation is not perfect, and the points on the graph do not completely align with the fitting line. However, the scatter plot is fairly flat, with the adjustment coefficient of 92.18%. Furthermore, a joint analysis of the growth rates of oil consumption in transport and GDP growth shows that the two variables evolve in synchronism (Figure 4). Thus, Figure 4 shows three distinct periods. The first was from 1975-1985, which corresponds to the period when fluctuations of greater amplitudes were recorded. They are positive. Also, the fluctuations in the growth of oil consumption in transport are broader than those of economic growth. During the second period of 1986-1994, the fluctuations are smaller, with the particularity of being relatively negative, especially those of GDP. During the third period, 1995-2014, GDP fluctuations are positive but very flat compared to the consumption of oil in transport. This analysis may suggest that economic growth is responding to fluctuations in oil consumption in transport and vice versa. As a result, it is important to know whether oil consumption in transport cause economic growth or whether economic growth leads to more oil consumption.

Figure 3. Scatter plot between Oil consumption in transport and GDP from 1975 to 2014



Source: Authors from IAE and WDI database

Figure 4. Transport's oil consumption growth rate and GDP growth from 1975 to 2014



Source: Authors from IAE and WDI database

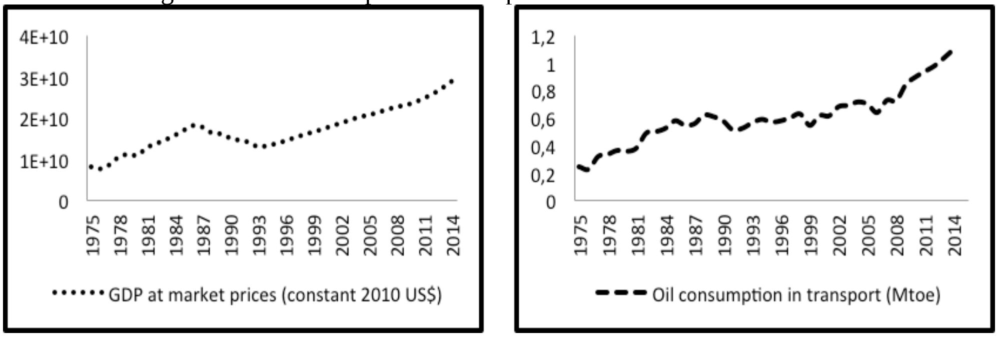
Therefore**, is there any causality relationship between oil consumption in transport and economic growth in Cameroon?** Specifically, does oil consumption in transport cause economic growth or do economic growth leads to more oil consumption? If it exists, is the causality unidirectional or bidirectional? However, answering these questions can help us to clearly understand the role of transportation's oil consumption in Cameroon's growth, which is meaningful for improving Cameroon's oil polices and promoting long-run growth.

The aim of this study is to demonstrate the causal empirical relationship between oil consumption in transport and economic growth in Cameroon. The paper analyzes a possible presence of a long-run equilibrium relationship between oil consumption in transport and economic growth. Compared to previous studies in this country, the essential contribution of this work is the identification of the response functions to shocks between oil consumption in transport and economic activity. Hence, this provides us with a basis for discussing oil consumption in transport policies in order to maintain a sustainable economic growth in Cameroon.

The remainder of this paper is organized as follows: Section 2 gives an overview of the Cameroon's oil consumption in transport and economic development; Section 3 provides a brief literature review on causality studies related to oil consumption and economic growth by presenting the theoretical role of transport in the economy. In Section 4, the methodology adopted in the study is presented. The data is described in Section 5.

2. Overview of the Cameroon's Oil Consumption in Transport and Economic Development

Figure 5. Oil consumption in transport and GDP from 1975 to 2014



Source: Authors from IAE database and WDI database

Between 1975 and 2014, oil consumption in transport in Cameroon have quadrupled (+334%). It rose from 0.252 million tons of oil equivalent (Mtoe) to 1.0944 Mtoe. This is the combination of population growth and transport infrastructure update. GDP over the same period tripled (+265%). It rose from nearly 7.873 billion US dollars to nearly 28.770 billion US dollars. There were three main phases in this development. During the first phase from 1975 to 1986, the country recorded one of its best performances with an average growth rate of 8%. This phase coincides with the discovery and exploitation of oil. During the second phase from 1987 to 1993, Cameroon experienced an irregular evolution with a low level of economic activity, with an average growth rate of -4.7%. This phase corresponds to the crisis of 1987 following the oil counter-shock of 1986. As from 1988, the Structural Adjustment Plans applied until 2003. The third phase from 1994 to 2014 was marked by the resumption of economic activity with an average growth rate of + 3.9%. This period was after the devaluation of the 1994 CFA franc and the end of the adjustments in 2006.

The volume of oil consumption in transport depends on the level of infrastructure. Cameroon's road infrastructure consists of over 52,000 kilometers divided into two networks: priority and non-priority. Cameroon priority roadways are not in good condition. A preliminary analysis has shown that out of the 11,120 kilometers of priority roads, only 250 kilometers are in a good state. In other words, only 2.2 % of the total is in good condition, while 45% of the primary network is in an average or bad condition. It is important to note that 65 % of Cameroon paved roads are more than 25 years old and the work carried out to date has been insufficient to maintain the quality of the network, which unfortunately has continued to degrade (Ministry of Public Works information system). Road transport accounts for more than 95% of petroleum products for the transport sector

(12% of final energy consumption). Super is only used in road transport at a rate of 59% against 41% for diesel. Apart from road transport, shipping and rail transport consume diesel in proportions of 1% and 2%, respectively. Air transport consumes only jet A1, at a rate of 2%.

Cameroon's road network is the transport backbone for Central Africa and the government has put in place a development strategy that should enable the country to create a reliable and efficient integrated infrastructure that will boost economic growth and foster sub-regional integration.

The doubling of paved roads is part of the activity of the National Council of Roads (Conaroute), which was set up in May 2005. Its mission is to facilitate the elaboration and implementation of national road policy by bringing together the elements from the public and private sector that uses Cameroon's roadways. Prospects are good for attaining this goal given that the authorities are determined to provide the country with good quality roads. From 2004-2011, the state has invested over US$481 million, which represent an expenditure of US$ 59.2 million a year. More than 14,000 kilometers of rural roads are in the process of rehabilitation, and we are also carrying out the progressive paving of rural roads and moderate traffic at a cost of US$ 41.67 million. At the same time, over 900 kilometers of paved roads have been rehabilitated at a cost of US$ 501.24 million, and another 1,500 km of roads have been paved at a total cost of US$ 1.97 billion.

Cameroon has 1,008 km of railways, narrow gauge and single-tracked line. The railway runs from the north of Cameroon to the country's economic capital, Yaoundé, and continuously extends to the west coast, the major Douala port of export.

At present, Cameroon railway system is carried out by 61 locomotives, 1,354 freight wagons and 76 passenger coaches. Freight transport comprises 90% of the rail network utilization (predominantly petroleum products, wood products and containerized traffic), which makes up approximately 1.8 million tons transport movement and about 1 million passengers transported a year.The rail network comprises of 5 major lines and serves as a vital means of economic and transport linkage between the north and south. Due to the road network, there is less development of the rail network in the north territory. Despite the fact that the main railway line between Yaounde and Douala is considered to be functioning effectively, the passenger traffic remains very few due to lots of uncontrolled competitions by many road hauliers which provide faster, more often, and eventually more attractive cost services.

3. Literature Review

The empirical literature provides mixed and conflicting evidence with respect to the energy consumption-growth nexus. The result of the discrepancy is largely due to the use of different econometric methods and time periods, besides country-specific heterogeneity in climate conditions, economic development, and energy consumption patterns, among other things. From a methodological perspective, four generations of contributions can be identified. First generation studies applied a traditional vector auto-regression (VAR) model based on the tradition of Sims (1972). For example, the seminar work of Kraft and Kraft (1978), using a VAR model, found evidence in favor of causality running from income to energy consumption in the United States for the period 1947-1974. Further, studies of the first generation examined the direction of causality assuming stationarity of the underlying variables (Erol & Yu, 1987; Yu & Choi, 1985; Abosedra & Baghestani, 1989).

Second generation studies accounted for non-stationarity in the data and performed co-integration analysis to investigate the long-run relationship between energy consumption and growth. This second generation literature, based on the Engle and Granger (1987) two-step procedure, studied pairs of variables to check for co-integration relationships and used estimated error-correction models to test for Granger causality (Nachane et al., 1988; Cheng & Lai, 1997; Glasure & Lee, 1998). Third generation studies used multivariate estimators based on the style of Johansen (1991). Johansen's multi-variate approach also allows for more than two variables in the cointegration relationship (Masih & Masih, 1997; Stern, 2000; Asafu-Adjaye, 2000; Soytas & Sari, 2003; Oh & Lee, 2004). Finally, fourth generation studies employ recently developed panel-econometric methods to test for unit roots and co-integration relations. This literature estimates panel-based error-correction models to perform Granger causality tests (Lee, 2005; Al-Iriani, 2006; Mahadevan & Asafu-Adjaye, 2007; Lee & Chang, 2007, 2008; Apergis & Payne, 2009; Lee & Lee, 2010; Costantini & Martini, 2010).

Some selected studies and their empirical setups are summarized in Table 1. Most of the studies dealing with the energy consumption-growth nexus focus on production side models, which often include capital stock and labour in addition to energy consumption and GDP. If one concentrates on energy demand, trivariate models with energy prices as an additional variable should be used (see Oh and Lee, 2004b). The studies by Masih and Masih (1998), Asafu-Adjaye (2000), Fatai et al. (2004) as well as Mahadevan and Asafu-Adjaye (2007) took the consumer price index (CPI) as a proxy of the energy price. However, as the CPI is known not to capture the energy price very well, we employ the real energy price index, such as that opined by Lee and Lee (2010) and Costantini and Martini (2010). Masih and Masih (1997) and Asafu-Adjaye (2000) previously used the vector error-correction model (VECM); Fatai et al. (2004) applied the autoregressive distributed lag (ARDL) approach; and Mahadevan and Asafu-Adjaye (2000), Lee and Lee (2010) as well as Costantini and Martini (2010) used a panel vector error-correction specification for the trivariate model.

Subsequently, few studies analyzed the relationship between energy consumption and economic growth in Cameroon. For example, Tamba et al. (2012) examined the causal relationship between diesel consumption and economic growth in Cameroon. Also, empirical results of the study confirm the presence of a long-run equilibrium relationship between diesel consumption and economic growth. The error correction model shows that an estimated 1% increase in economic growth causes a rise in diesel consumption of 1.30% in the long- run. The overall results show that there exists bidirectional causality in the long-run relationship and no causality exists in the short-run relationship between diesel consumption and economic growth at the 5% level of significance.

Table 1. Overview of selected studies

Study	Method	Countries	Results
Kraft and Kraft (1978)	Bivar. Sims	USA	Growth →Energy
Yu and Choi (1985)	Causality Bivar;	South Korea	Growth →Energy
	Granger test	Philippines	Energy→ Growth
Erol and Yu (1987)	Bivar. Granger test	USA	Energy → Growth
Yu and Jin (1992)	Bivar. Granger test	USA	Energy → Growth
Masih and Masih (1996)	Trivar. VECM	Malaysia, Singapore	Energy→ Growth
		& Philippines	Energy↔ Growth
		India	
Glasure and Lee (1998)	Bivar. VECM	Indonesia	Energy →Growth
		Pakistan	Growth →
Masih and Masih (1998)	Trivar. VECM	South Korea	EnergyGrowth →
		& Singapore	Energy
Asafu-Adjaye (2000)	Trivar. VECM	Sri Lanka & Thailand	Energy↔Growth
		India & Indonesia	
Hondroyiannis et al. (2002)	Trivar. VECM	Thailand&Philippines	Energy → Growth
Soytas and Sari (2003)	Bivar. VECM	Greece	Energy→ Growth
Fatai et al. (2004)	Bivar. VECM	Argentina	
	Bivar. Toda and	South Korea Indonesia &	Energy↔Growth
	Yamamoto (1995)	Poland	Energy↔ Growth
		Canada, USA & UK	Energy↔ Growth
		Turkey	Energy↔Growth
		Indonesia & India	Energy↔Growth
Oh and Lee (2004b)		Thailand&Philippines	Energy ↔ Growth
Wolde-Rufael (2004)	Trivar. VECM	South Korea	
	Bivar. Toda and	Shanghai	Energy ↔Growth
Lee (2005)	Yamamoto (1995)		Growth↔ Energy
	Trivar. Panel	18 developing nations	
Al-Iriani (2006)	VECM)		Energy↔Growth

Lee and Chang (2008a)	Bivar. Panel VECM	Gulf Cooperation C.	
	Mulitv. Panel	16 Asian countries	Energy↔Growth
	VECM		
Lee et al. (2008)	Trivar. Panel		Energy↔Growth
	VECM	22 OECD countries	
Narayan and Smyth (2008)	Multiv. Panel		Energy↔Growth
	VECM	G7 countries	
Apergis and Payne (2009a)	Multiv. Panel		
	VECM	11 countries of the	Energy→Growth
		Commonwealth of	
Apergis and Payne (2009b)	Multiv. Panel	Independent States	Energy↔Growth
	VECM	6Central American	
Lee and Lee (2010)	Multiv. Panel	countries	
		VECM 25 OECD	
		countries	

Notes:X→Y means variable X Granger-causes variable

4. Methodology

Using economic theory to describe the relation between the variables couldn't offer the strict definition for dynamic relation between the variables frequently. Besides, endogenous variables may also appear on both sides of an equation, which make the estimation and inference complicated. To solve these problems, we will use a vector error to analyze energy consumption and economic growth in Cameroon. This approach will be a five-step modern time series techniques: Unit root tests, co-integration analysis, and Granger-causality based on error correction model. We also use impulse response function and variance decomposition to portray the correlations between variables.

Step 1:Unit Root Tests

The first step involves applying unit root tests. According to Engle and Granger (1987), the series x and y of a non-stationary linear combination with the same order of integration may be stationary. The Augmented Dickey-Fuller test (ADF) will be used to identify the presence of unit root in series. Here, we will try to test the null hypothesis that a time series is I(1) against the alternative that it is I(0), assuming that the dynamics in the data have an ARMA structure. Therefore, the ADF test is based on the least squares estimation of three models (Mata, 2007):

$$\Delta x_t = (\rho - 1) x_{t-1} + \sum_{j=2}^{k} \varphi_j \Delta x_{t-j+1} + \varepsilon_t \qquad [1]$$

$$\Delta x_t = (\rho - 1) x_{t-1} + \sum_{j=2}^{k} \varphi_j \Delta x_{t-j+1} + \gamma + \varepsilon_t \qquad [2]$$

$$\Delta x_t = (\rho - 1) x_{t-1} + \sum_{j=2}^{k} \varphi_j \Delta x_{t-j+1} + \gamma + \beta t + \varepsilon_t \qquad [3]$$

Where D is the difference operator, k is the auto-regressive lag length, *g* is a constant, *b* is a coefficient on a time trend, and *r* is a coefficient of interest. When these series are found to be non-stationary, we take the first difference and we apply the ADF tests again on the differenced data and so on.

Step 2: Johansen Co-integration Tests

The second step involves examining co-integration relationship among the variables using vector autoregressive (VAR) approach of Johansen (1991, 1988). The analysis of the co-integration clearly identifies the number of long-run equilibrium relationships between integrated variables of the same order. Two sets x and y are called co-integrated if they are assigned a stochastic trend of the same order of integration and/ or some linear combination of them has a lower order of integration. This test uses two statistics: statistics of the trace and the maximum eigenvalue. The asymptotic distributions of these statistics are non-standard.

Step 3: Granger-Causality Test

The third step involves building Granger-causality tests within an error correction term. At the theoretical level, co-integration implies the existence of Granger-causality between two variables. It can indicate the direction on the causality relationship. This causal relationship can be analyzed using the Granger causality test, which is based on the vector error correction model (VECM).

According to the Granger representation theorem, any co-integrated system implies the existence of an error correction mechanism that prevents the variable to deviate from their long-run equilibrium. In our case, if the three variables studied, namely: growth of GDP per capita, the logarithm of infrastructure transport, and the logarithm of energy consumption, are co-integrated, we deduce that there is an error correction mechanism.

The error correction model is a particular form of autoregressive distributed lag model (ARDL). It can be interpreted in this context as a fit model. Like the adjustment model, the coefficient of error is only relevant when it is significant and between -1 and 0.

Step 4: Impulse Response Function

The generalized impulse response functions trace out responsiveness of the dependent variables in the VAR to shocks to each of the variables. For each variable from each equation separately, a unit shock is applied to the error, and the effects upon the VAR system over time are noted (Brooks, 2002).

Step 5: Variance Decomposition

Variance decomposition gives the proportion of the movements in the dependent variables that are due to their "own" shocks, versus shocks to the other variables.

5. Data Description

This paper makes use of an annual data covering the period 1975-2014. We selected the current US dollar gross domestic product (GDP) of Cameroon in millions dollars as an indicator which measures the total economic growth. Also, it uses oil consumption in transport (EC) in millions tons of oil equivalent (Mtoe) as indicator which measures the consumption of energy in transport. GDP is adjusted at 2010's constant price according to the indices of gross domestic product. Also, GDP and EC came respectively from the World Bank indicators and International Energy Agency database from 1975 to 2014. All data are processed by logarithm (respectively LGDP for logarithm of gross domestic product and LEC for logarithm of Oil consumption of energy in transport) in order to maintain the stability of data and correct heteroscedasticity. Table 2 below presents descriptive statistics for the samples.

Table 2. Descriptive statistics over 1975-2014

Variables	LEC	LGDP
Mean	-0.556283	23.49474
Median	-0.538493	23.49596
Maximum	0.090206	24.08261
Minimum	-1.467938	22.73019
Std. Dev.	0.347251	0.323155
Skewness	-0.607226	-0.409413
Kurtosis	3.533697	2.917575
Jarque-Bera	2.932878	1.128785
Probability	0.230746	0.568706
Sum	-22.25132	939.7894
Sum Sq. Dev.	4.702738	4.072749
Observations	40	40

6. Empirical Results

6.1. Results of Unit Root Tests

The table below presents the results of unit root test on logarithmic transformation of the levels and first differences of GDP and Oil consumption series. According to Augmented Dickey Fuller test, the null hypothesis tested in Model 3 (constant with trend) on the two series, LGDP and LEC, cannot be rejected at the % level of significance. The trend coefficient is not rejected for LGDP and LEC series. So, we test the lagged endogenous variable coefficient. We found out that they are not rejected for the two series. Finally, Model 3 was retained by the unit root test for the two series. Stationarity is obtained by running the similar test on the first difference of the variables. This indicates that the LGDP and LEC variables are individually integrated of order one. Phillips perron and KPSS confirms that results.

Table 3. Unit Root Test

	Augmented Dickey Fuller (ADF)			Phillips Perron (PP)			Kwiatkowski Phillips Schmidt Shin (KPSS)	
Variable	**Model 1 : None**	**Model 2 : Constant**	**Model 3 : Constant with Trend**	**Model 1 : None**	**Model 2 : Constant**	**Model 3 : Constant with Trend**	**Model 2 : Constant**	**Model 3 : Constant with Trend**
LGDP	2.256 (1)	-2.206 (1)	-2.088 (2)	2.440 [4]	-1.319 [4]	-2.047 [4]	0.679*** [5]	0.086*** [5]
LEC	-3.161*** (0)	-1.565 (0)	-2.545 (0)	-3.615*** [3]	-1.582 [3]	-2.466 [1]	0.718*** [5]	0.123*** [4]
D(LGDP)	-3.111*** (0)	-3.988*** (0)	-4.047** (0)	-3.121*** [2]	-4.178*** [3]	-4.259*** [3]	0.127*** [4]	0.118*** [4]
D(LEC)	-6.034*** (0)	-7.376*** (0)	-7.487*** (0)	-6.114*** [3]	-7.298*** [1]	-7.392*** [1]	0.194*** [3]	0.162*** [4]

Note: ***;**;* respectively denotes significant at 1%, 5% and 10% significance level. The figure in parenthesis () represents optimum lag length selected based on Akaike Info Criterion. The figure in bracket [] represents the Bandwidth used in the Phillips Perron and KPSS test selected based on Newey-West Bandwidth criterion.

6.2. Results of Cointegration Tests

After testing if the variables are stationary at first order, the next step is to estimate the VECM. Firstly, we need to select an optimum lag of VECM before performing the Johansen Cointegration test. As shown in table 4, 5 and 6, we checked the autocorrelation of the error terms in each regression by using the White heteroscedasticity test, the autocorrelation test, and the normality test. We concluded for joint test that error terms is free from autocorrelation problem.

Table 4. VEC Residual White Heteroscedasticity Test

Chi-sq	df	Prob.
36.85151	36	0.4293

Table 5. VEC Residual Serial correlation LM

Lags	**LM-Stat**	**Prob**
1	9.101781	0.0586
2	5.437321	0.2453
3	4.621265	0.3284
4	0.988135	0.9116
5	5.720645	0.2210
6	2.674226	0.6137
7	2.343522	0.6729
8	2.775150	0.5961
9	3.093410	0.5423
10	1.850112	0.7633
11	1.140267	0.8878
12	4.711506	0.3182

Probs from chi-square with 4 df.

Table 6. VEC Residual Normality Tests

Component	Skewness	Chi-sq	df	Prob.
1	1.143506	8.063565	1	0.0045
2	-0.608807	2.285650	1	0.1306
Joint		10.34922	2	0.0057
Component	Kurtosis	Chi-sq	df	Prob.
1	7.678219	33.74050	1	0.0000
2	2.990516	0.000139	1	0.9906
Joint		33.74064	2	0.0000

Component	Jarque-Bera	df	Prob.
1	41.80407	2	0.0000
2	2.285789	2	0.3189
Joint	44.08986	4	0.0000

Figure 6. Correlogram of Residual Test

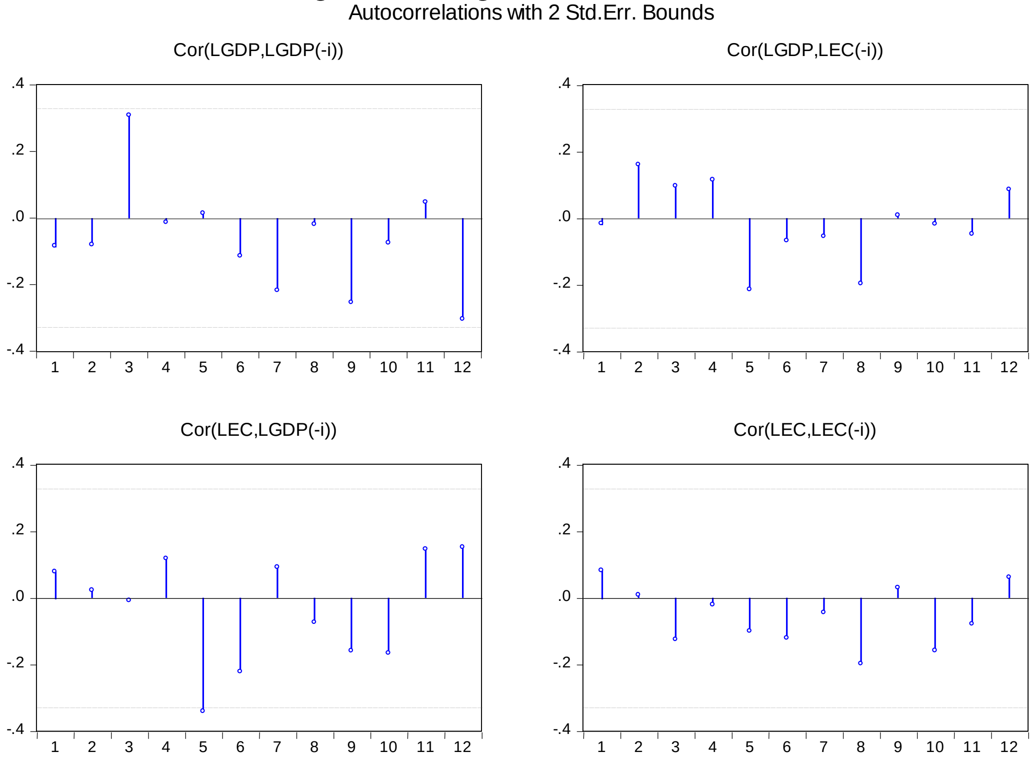


Table 7. Number of cointegration

Trace test	Eigenvalue	Statistic	5% Critical Value
None	0.215591	14.22345	18.39771
At most 1*	0.132026	5.238942*	3.841466
Maximum eigenvalue test	Eigenvalue	Statistic	5% Critical Value
None	0.215591	8.984510	17.14769
At most 1*	0.132026	5.238942*	3.841466

Note: * denotes rejection of the hypothesis at the 0.05 level

Table 7 presents the Johansen cointegration test. The result shows that both trace test and Max Eigen test are statistically significant to reject the null hypothesis of $r \leq 1$ at 5% significance level. Therefore, only one long run cointegration relationship exists between LGDP and LEC.

Table 8 reveals that the coefficient associated with the restoring force is negative (1.29) and significantly different from zero at the statistical threshold of 5% (student's t is greater than the tabulated value). There is therefore an error-correcting mechanism. This mechanism indicates the convergence of the trajectories of LGDP series towards the long-term target. Thus, the shocks on gross domestic product in Cameroon are corrected to 1.29% by feedback effect. In other words, the long run equation revealed that an estimated 1% increase in economic growth causes a rise in oil consumption in transport of 1.29% at the 5% level. We found the same results as opined by Tamba et al. (2012). According to their work, they used diesel consumption while we used energy consumption in transport. It is therefore obvious that similar results will be obtained if we consider diesel as the fuel mostly used in transport in Cameroon. To provide arguments for our analysis, we plan to construct an impulse response function and a decomposition of the variance.

Table 8. Estimate of Vector error correction model
Standard errors in ( ) & t-statistics in [ ] and D is first difference and one lag value (-1)

CointegratingEq:	CointEq1	
LGDP(-1)	1.000000	
LEC(-1)	-1.299662 (0.28875) [-4.50099]	
@TREND(75)	0.008417	
C	-24.38019	
Error Correction:	D(LGDP)	D(LEC)
CointEq1	0.010769 (0.09280) [0.11605]	0.374872 (0.13078) [2.86634]
D(LGDP(-1))	0.446531 (0.19082) [2.34009]	0.248264 (0.26893) [0.92316]
D(LGDP(-2))	-0.134111 (0.16183) [-0.82874]	-0.352077 (0.22807) [-1.54374]
D(LEC(-1))	0.209917 (0.11310) [1.85597]	0.043804 (0.15940) [0.27480]
D(LEC(-2))	0.058749 (0.10565) [0.55609]	0.058521 (0.14889) [0.39304]
C	0.007114 (0.01991) [0.35735]	0.031260 (0.02806) [1.11417]

@TREND(75)	0.000189	2.24E-05
	(0.00074)	(0.00105)
	[0.25407]	[0.02138]
R-squared	0.394231	0.335970
Adj. R-squared	0.273077	0.203164
Sum sq. resids	0.065003	0.129111
S.E. equation	0.046548	0.065603
F-statistic	3.253969	2.529778
Log likelihood	64.86778	52.17223
Akaike AIC	-3.127988	-2.441742
Schwarz SC	-2.823220	-2.136974
Mean dependent	0.033072	0.033065
S.D. dependent	0.054596	0.073491

6.3. Results of Granger-causality Test

We can reject the hypothesis that LEC does not Granger cause LGDP. The p value is less than 5%. We also can reject the hypothesis that LGDP does not Granger cause LEC. Thus, the p value is less than 10%. Therefore, it appears that Granger causality runs two-way from LGDP to LEC and not the other way. Table 9 shows that there exists a bidirectional causality in long-run relationship and there is no causality in the short-run relationship at the 5% level of significance. However, Table 10 shows that there is no relationship between LGDP and LEC in the short term. The Wald test is not significant. As a result, the p value is more than 10%.

Table 9. Pairwise Granger Causality test

Null Hypothesis	Obs	F-Statistic	Prob.
LEC does not Granger Cause LGDP	35	3.56196	0.0150**
LGDP does not Granger Cause LEC		2.11005	0.0991*

Note: ***; **; * denotes respectively 1%; 5% and 10% significance level

Table 10. VEC Granger Causality/Block Exogeneity Wald Test

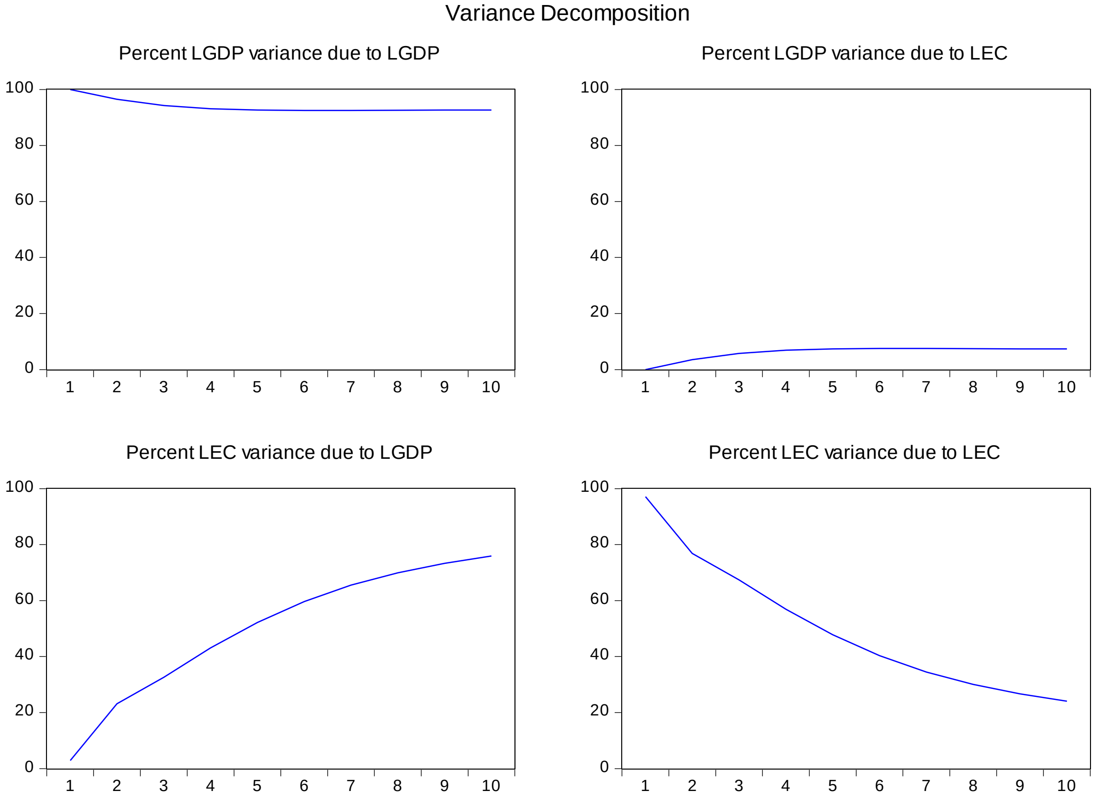
VEC Granger Causality/Block Exogeneity Wald Tests			
Included Observations: 37			
Dependent variable: D(LGDP)			
Excluded	Chi-sq	df	Prob.
D(LEC)	3.531512	2	0.1711
All	3.531512	2	0.1711
Dependent variable: D(LEC)			
Excluded	Chi-sq	df	Prob.
D(LGDP)	3.015189	2	0.2214
All	3.015189	2	0.2214

Note: ***; **; * denotes respectively 1%; 5% and 10% significance level

6.4. Results of Variance Decomposition and Impulse Response Function (IRF)

The result of VECM indicates the exogeneity or endogeneity of a variable in the system and the direction of Granger-causality within the sample period. However, it does not provide us with dynamic properties of the system. The analysis of the dynamic interactions among the variables in the post-sample period was conducted through variance decompositions and impulse response functions (IRFs).

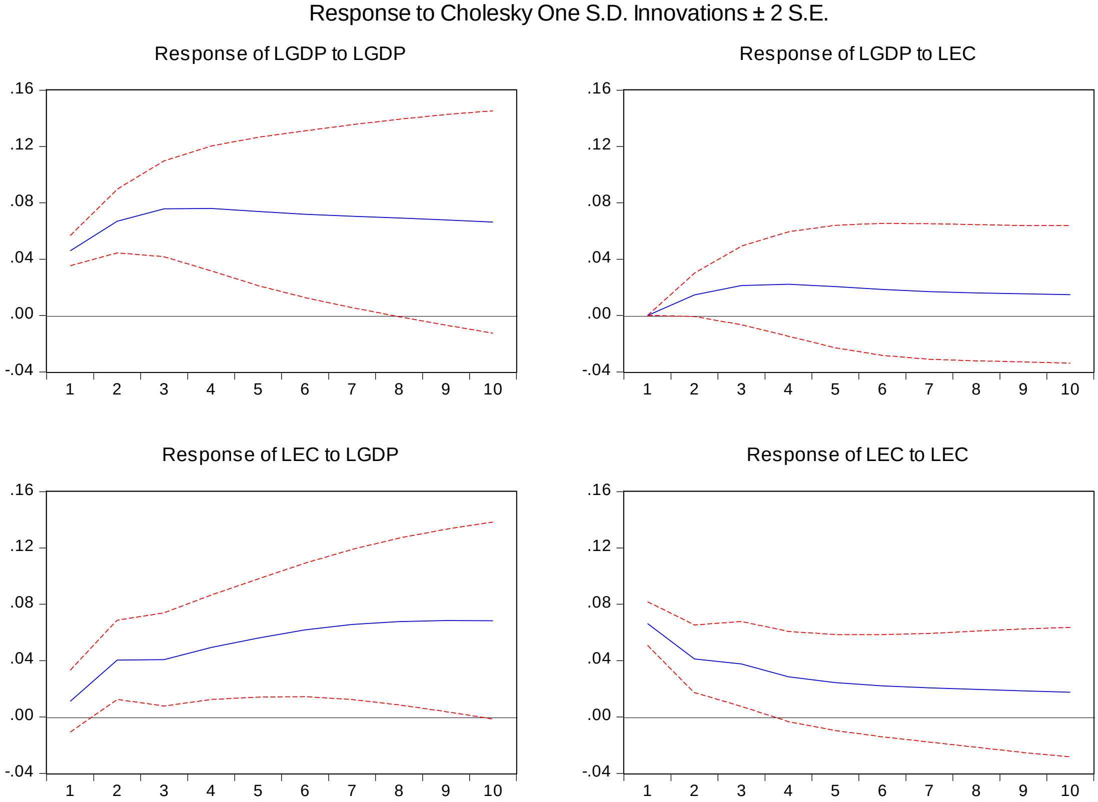
Figure 7: Variance Decomposition



The decomposition of the variance indicates that the variance of the prediction error of LGDP is due to 92.6% of its own innovations and 7.4% of that of LEC. The variance of the prediction error of LEC is due to 76% at LGDP and 24% at LEC. This dissymmetry confirms the result of the Granger causality test. Indeed, it has a bidirectional direction from LGDP to LEC.

The results of IRF appear in four separate tables. We analyze the response to LGDP to a shock in itself and a shock in LEC. In the same way, we also analyze the response to LEC to a shock in itself and a shock in LGDP. More interesting is how LGDP responds to shocks in the LEC, and vice versa. A shock to LEC affects LGDP for one period, but dies out very slowly after 10 periods. A shock to the LGDP creates a bigger response in LEC, though once again it tends to a steady state close to zero.This result confirms that an increase in the GDP growth rate will be accompanied by a rise in oil consumption in transport.

Figure 8. Impulse response function



7. Discussion and Concluding Remarks

This paper focuses on casting light on the causal relationship between oil consumption in transport and economic growth in Cameroon. This paper uses an annual data covering the period 1975-2014, a five-step modern time series techniques. These, however, include the Unit root tests, co-integration analysis, and Granger-causality based on error correction model. As a robustness test, we have introduced the functions of impulse responses and the decomposition of the variance to portray the correlations between variables. The main result highlighted in this paper can be presented as follows:

1. We point out the presence of a long-run equilibrium relationship between oil consumption in transport and economic growth.

2. We show that there exists bidirectional causality in long-run relationship and no causality exists in the short-run relationship at the 5% level of significance.
3. The error correction model find out that an estimated 1% increase in economic growth causes a rise in oil consumption in transport of 1.29% in the long run.
4. The decomposition of the variance indicates that the variance of the prediction error of LGDP is due to 92.6% of its own innovations and 7.4% of that of LEC. The variance of the prediction error of LEC is due to 76% at LGDP and 24% at LEC. This dissymmetry confirms the result of the Granger causality test.
5. The impulse response function confirms that a shock to LEC affects LGDP for one period, but dies out very slowly after 10 periods. While a shock to the LGDP creates a bigger response in LEC, though once again it tends to a steady state close to zero.

Overall, the results imply that oil consumption in transport stimulates economic growth; in addition, increased oil consumption in transport requires real income. In fact, the change in energy consumption following an increase in real income is greater than a change in the rate of economic growth following a change in energy consumption in transport. The low level of economic growth after a variation of oil consumption leads to the fact that there are many other factors that is contributing to economic growth, and oil consumption in transport is only one of those factors.

These findings have important implications for policy in Cameroon. As a result, the government could deal with growing oil demand by supporting oil refineries through public funded subsidies.

References:

1. Abosedra, S. & Baghestani, H. (1989). “New evidence on the causal relationship between US energy consumption and Gross National Product” *Journal of Energy Development* 14, 285–292.
2. Al-Iriani, M. (2006). “Energy–GDP relationship revisited: An example from GCC countries using panel causality” *Energy Policy* 34 (17), 3342–3350.
3. Apergis, N. & Payne, J. E. (2009a). “Energy consumption and economic growth: Evidence from the Commonwealth of Independent States” *Energy Economics* 31 (5), 641–647.
4. Apergis, N. & Payne, J. E. (2009b). “Energy consumption and economic growth in Central America: Evidence from a panel cointegration and error correction model” *Energy Economics* 31 (2), 211–216.

5. Asafu-Adjaye, J. (2000). "The relationship between energy consumption, energy prices and economic growth: Time series evidence from Asian developing countries" *Energy Economics* 22 (6), 615–625.
6. 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.
7. Costantini, V. & Martini, C. (2010). "The causality between energy consumption and economic growth: A multi-sectoral analysis using non-stationary cointegrated panel data" Energy *Economics* 32 (3), 591–603.
8. Energy Information Administration (EIA) (2015). *Annual Energy Outlook 2015*. Washington D.C.
9. Engle, R. F. & Granger, C. W. J. (1987). "Cointegration and Error Correction. Representation, Estimation, and Testing:" *Econometrica*, 55, 251-276.
10. Erol, U. & Yu, E. S. H. (1987). Time series analysis of the causal relationships between U.S. energy and employment. Resources and Energy 9 (1), 75–89.
11. Fatai, K., L. Oxley, & 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 (3-4),431- 445.
12. Glasure, Y. & Lee, A. (1998). Cointegration, error-correction and the relationship between GDP and energy: The case of South Korea and Singapore. Resource and Energy Economics 20 (1), 17–25 Harris, R. I. D. and R. Sollis (2003). Applied time series modelling and forecasting.
13. Hondroyiannis, G., Lolos, S., & Papapetrou, G. (2002). Energy consumption and economic growth: Assessing the evidence from Greece. Energy Economics 24, 319–336. HPSF, (2009). *HPSF Statistic*, Petroleum Statistic Office Study.
14. International Energy Agency Database 2016.
15. Johansen, S. (1988). "Statistical Analysis Of Cointegrating Vectors".*Journal of Economic Dynamics and control*, 12, 231-254.
16. Johansen, S. (1991). "Estimation and Hypothesis Testing Of Cointegration Vectors in Gaussian Vectors Autoregressive Models". *Econometrica*, 59, 1551–1580.
17. Kraft, J. & Kraft, A. (1978). "On the relationship between energy and GNP" Journal *of Energy and Development* 3, 401–403.

18. Lee, C. (2005). “Energy consumption and GDP in developing countries: A cointegrated panel analysis” *Energy Economics* 27 (3), 415–427.
19. Lee, C. & Chang, C. (2007). “Energy consumption and GDP revisited: A panel analysis of developed and developing countries” *Energy Economics* 29 (6), 1206–1223.
20. Lee, C. & Chang, C. (2008a). “Energy consumption and economic growth in Asian economies: A more comprehensive analysis using panel data” *Resource and Energy Economics 30* (1), 50–65.
21. Lee, C., Chang, C., & Chen, P. (2008b). “Energy-income causality in OECD countries revisited: The key role of capital stock” *Energy Economics* 30 (5), 2359–2373.
22. 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.
23. 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 (4), 2481–2490.
24. Masih, A. & Masih, R. (1996). “Energy consumption, real income and temporal causality Results from a multi-country study based on cointegration and error-correction modeling techniques” *Energy Economics*18, 165–183.
25. Masih, A. M. M. & Masih, R. (1997). “On the temporal causal relationship between energy consumption, real income, and prices: Some new evidence from Asian-energy dependent NICs based on a multivariate cointegration vector error-correction approach” *Journal of Policy Modeling 19* (4), 417–440.
26. 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 (11), 1511–1531.
27. Narayan, P. K. & Smyth, R. (2008). Energy consumption and real GDP in G7 countries: New evidence from panel cointegration with structural breaks. *Energy Economics* 30 (5), 2331–2341.
28. Oh, W. & Lee, K. (2004a). “Causal relationship between energy consumption and GDP revisited: The case of Korea 1970-1999” *Energy Economics* 26 (1), 51–59
29. Oh, W. & Lee, K. (2004b). “Energy consumption and economic growth in Korea: Testing the causality relation” *Journal of Policy Modeling* 26 (8-9), 973–981.

30. Ramanathan, R. & Parikh, J. K. (1999). "Transport Sector in India: An Analysis in the Context of Sustainable Development". *Transport Policy*, 6, 35-45.
31. Reddy, A. K. N., Anand, Y. P., & D'Sa, A. (2001). "Energy for a Sustainable Road/ Rail Transport System in India". *Energy for Sustainable Development*, 4, 29-44.
32. Samimi, R. (1995). "Road Transport Energy Demand in Australia: A Cointegration Approach". *Energy Economics*, 17, 329-339.
33. Soytas, U. & Sari, R. (2003). Energy consumption and GDP: Causality relationship in G-7 countries and emerging markets. *Energy Economics* 25 (1), 33–37.
34. Stern, D. I. (2000). "A multivariate cointegration analysis of the role of energy in the US macroeconomy" *Energy Economics* 22 (2), 267–283.
35. Sims, C. A. (1972). "Money, Income and Causality", *the American Economic Review, 62(4), 540-552.*
36. Tamba, J. G., Njomo, D., Limanond, T., & Ntsafack, B. (2012). "Causality analysis of Diesel Consumption and economic growth in Cameroon" *Energy policy, 45, 567-575.*
37. Wolde-Rufael, Y. (2004). "Disaggregated energy consumption and GDP, the experience of Shangai, 1952–1999" *Energy Economics* 26, 69–75.
38. World Development indicator database 2016.
39. Yu, E. & Choi, J. (1985). "The causal relationship between energy and GNP: An international comparison" *Journal of Energy and Development* 10, 249–272.
40. Yu, E. & Jin, J. (1992). "Cointegration tests of energy consumption, income and employment" *Resources and Energy* 14, 259–266.