BOLIVIA'S ENERGY CONSUMPTION AND ECONOMIC GROWTH PROFILE: IS THERE A LINK?

Ismail SOILE*[1]*, Centre for Energy, Petroleum and Mineral Law & Policy (CEPMLP), University of Dundee
Kareem A. ARIKEWUYO*[2]*, Fountain University, Osogbo, Nigeria

The fundamental importance of energy for socio-economic existence cannot be over-emphasized. With an annual average growth rate of 3.6% over the period of 1998 and 2008, the Bolivian economic statistics shows that over 60% of the country's GDP growth rate can be attributed to its export sector. However, energy consumption also grew significantly over the same period. Thus we seek to establish the directional causality between energy consumption and economic growth in Bolivia using secondary annual data for the period of 1971 to 2010. The Granger-causality tests indicate that there is an unidirectional causality that runs from economic growth to energy consumption with no feedback. The study, therefore, recommends that policies meant to manage growing energy demand can be instituted without obstructing growth in Bolivia. Energy taxation and pricing reform can help raise additional revenue for development.

Key words: *economic growth, energy, reform, energy consumption, Bolivia, taxation.*

Importanța fundamentală a energiei pentru existența socio-economică nu poate fi supra-accentuată. Cu o rată medie de creștere anuală de 3,6% în perioada anilor 1998-2008, statisticile economice boliviene arată că peste 60% din rata de creștere a PIB-ului țării poate fi atribuită sectorului său de export. Cu toate acestea, consumul de energie, de asemenea, a crescut în mod semnificativ în aceeași perioadă. Astfel, vom căuta să stabilim cauzalitatea direcțională între consumul de energie și creșterea economică în Bolivia, folosind date anuale secundare pentru perioada anilor 1971-2010. Testele de cauzalitate Granger indică asupra faptului că există o cauzalitate unidirecțională, care trece de la creșterea economică la consumul de energie, fără nici un feedback. Prin urmare, studiul recomandă că politicile, menite să gestioneze cererea crescândă de energie, pot fi instituite fără a obstrucționa creșterea în Bolivia. Impozitarea energiei și reforma de stabilire a prețurilor pot contribui la creșterea veniturilor suplimentare pentru dezvoltare.

Cuvinte-cheie: *creșterea economică, energia, reforme, consumul de energie, Bolivia, impozitare.*

Фундаментальное значение энергии для социально-экономического существования не может быть переоценена. Со средним годовым темпом роста в 3,6% за период с 1998 по 2008, боливийская экономическая статистика показывает, что более 60% от роста ВВП страны можно отнести к экспортному сектору. Тем не менее, потребление энергии, также, значительно увеличилось за тот же период. Таким образом, авторы стремятся установить причинно-следственную связь между потреблением энергии и экономическим ростом в Боливии, используя вторичные ежегодные данные за период 1971-2010 гг. Тест Грэнджера на причинность показывает, что существует однонаправленная причинность, которая идет от экономического роста к потреблению энергии без обратной связи. Таким образом, исследование рекомендует, что политика по управлению растущего спроса на энергию может быть реализована без препятствий для роста в Боливии. Налогообложение энергетики и реформа ценообразования может способствовать привлечению дополнительных доходов для развития.

Ключевые слова: *экономический рост, энергетика, реформа, потребление энергии, Боливия, налогообложение.*

JEL Classification: N76, O10, Q01, Q40, Q41.

[1] ***© Ismail SOILE, iosoile@gmail.com***
[2] ***© Kareem A. ARIKEWUYO, abees4you@yahoo.com***

Introduction. That energy is a fundamental requirement for human socio economic existence is not an exaggeration. Energy is vital for sustaining national economies and a required ingredient for both human system of livelihood and continued existence. As an important instrument for social development, energy enhances living standards among population. A nation's economic development is closely connected to the amount of energy consumed such that any observed increase in economic development may be a consequence of higher energy consumption. Conversely, a higher level of energy consumption could also be consequence of an efficient energy use which will invariably lead to reduced energy consumption, sometimes refer to as economic performance gain. Therefore, as energy consumption can help to determine the economic development, so also can the level of economic development be indicated by the pattern of energy consumption.

The link between energy consumption and national development from the policy perspective remains a contestable issue till present. An agreement between scholars remains elusive because of contradictory empirical findings in several studies. For instance, a study by Stern (2000) extending an earlier effort Stern (1993) on USA post war economy discovered a multivariate co-integration tie between Gross domestic product (GDP) and energy. He concluded once more that GDP is not granger caused by energy. However, by applying a quality weighted index of energy input, it was discovered that growths do granger cause GDP. Nevertheless, the new result affirms Stern (1993) findings but sharply contrast with the outcome of a bivariate analysis by Yu and Jin (1992) on the same US economy using different methodology though.

There are four major theoretical postulates with respect to the way energy interacts with the economy in a given society. While an unidirectional causality from economic development to energy consumption suggests little dependence of a nation on energy consumption, an unidirectional causality from energy consumption to economic growth on the other hand confirms a relationship exists where economic growth depends on energy consumption. It is also possible for both causality to run both ways between energy consumption and growth. In this case, a bi – causality exists and neutrality hypothesis is where causality runs neither way.

Whatever the outcome, the ensuing causal relation between energy consumption and economy can be of immense use in terms of countries formulation of energy policy in the specific area of demand management, pricing and its reform process. As widely researched as the issue of energy – economy interdependence appear, available records point to no investigation on the causal relationship between energy consumption and economic development in Bolivia. Yet, Bolivia is perhaps the poorest country within the Latin American region with an estimated population and GDP of about 10.2 millionand $23.67 billion respectively (CIA Fact book, 2012). About 80% of Bolivia's energy consumption comes from fossil fuels and the country has been experiencing rising energy consumption in recent years which has dragged Bolivia into the league of net oil importer.

Between 2005 and 2010, Bolivia GDP and energy consumption grew at an average of about 5% and 10% respectively. These trends definitely allow for further curiosity; is Bolivia’s energy consumption increase responsible for its economic growth profile and vice versa or do the variables jointly determine each other? This is the prime focus of the proposed investigation in this paper. It is believed that answers to this line of questions can assist the Bolivian authorities in the area of energy policy formulation in a country where the energy sector is of high political and economic significance.

This study shall commence henceforth with a literature review and brief account of Bolivia’s energy profile, chapter three will show the analysis and chapter four will conclude.

This study shall commence henceforth with a literature review and proceed in the third section to give a brief account of Bolivia’s energy and economy profile. Section four contains all the Analysis while the study is concluded in section five.

Literature review. Rigorous studies in the last quarter century have trailed causal relationship between economic development and energy consumption. As proficiency increased with time series analysis, many studies have determined the causal relationship of economic development and energy consumption by Granger causality concept. However findings have not established consensus, diverse results have emanated from both different countries and dissimilar periods in same country.

In a typical comparative study on energy use and its relationship with GDP of less developed nations, Lee (2005) utilises a panel data based error correction method and detects that both long and short run causalities points to energy consumption granger causing GDP. Lee however cautioned that different outcomes may be acquired for a single country because causality tests have been proven to be data and lag

length sensitive. Soytas and Sari (2003) established a bidirectional causality relationship between energy consumption and GDP in Argentina, a one-way causation flowing from energy consumption to economic growth in some OECD countries namely Japan, Turkey and Germany but causality in the reverse direction in Italy and Korea, i.e. from economic growth to energy consumption.

How energy consumption and economic growth correlate in India between from 1970-2005 was investigated by Mallick (2009) with granger causality method. The study's outcome implied an unidirectional granger causality flow from coal consumption to economic growth while economic growth granger was found to granger caused demand increase for electricity alongside oil consumption. The study conclusion was however vague regarding India's energy consumption and economic development nexus due to conflicting evidence from the outcome of the variance decomposition and Vector Auto-Regression analysis. Much earlier, Paul and Bhattacharya (2004) discovered a bi-directional causality between energy growth and energy consumption in India with data ranging from 1950 to 1996 whereas, Oh and Lee (2004) using vector error correction model with 1970 to 1999 data on Korea discovered long run bi-directional causality between energy and economic development but a short-run unidirectional causal relationship emanating in the reverse direction from energy to GDP.

In a study by Narayan and Smith (2007) investigating the case of G7 countries, employ a combination of Granger causality, panel unit root and co-integration framework to study the existing link among energy consumption, capital formation and real GDP. The outcome revealed that in the long run real GDP was granger caused by both energy consumption and capital formation. A percentage increase in both energy consumption and capital formation caused increase in real GDP by 0.12 to 0.39% and 0.1 to 0.28% respectively.

Odhiambo (2010) studied the causal relationship between energy consumption and GDP in three sub Saharan country namely South Africa, Kenya and Congo (DRC). The outcome displayed an unidirectional causality which flow from energy consumption to economic growth for Kenya and South Africa, while Congo produced a one way causality flowing from economic growth to energy. What this implies for energy conservation policy is that why Kenya and South Africa require guidelines which will increase supply of energy for meeting long-run demand for energy, Congo on the other hand may execute energy demand management policies without drastically disrupting its economic growth.

Shiu and Lam (2004) studying the relationship between electricity and economic growth in China used granger causality test to analyse data from 1971 to 2000 and discovered the presence of one way causality from Chinese electricity consumption to China's GDP. This gave substance to the fact that industrial sector's electricity consumption brought about growth especially from the 1970 to 2000. The author noted that about 80% of electricity consumed in this period was attributable to the industrial sector. A key economic driver of China's economy is industrial production and it is not surprising to see a growing industrial demand for electricity resulting in aggregate rise in energy consumption and consequently leading to increase in economic growth. To curb any supply shock in electricity which could potentially weaken China's economic development, the authors recommends that electricity generation capacity needs to be augmented. These findings conform remarkable well with that of Yuan et al (2007) who use data from 1978 to 2004 and found unidirectional causality from Chinese electricity consumption to china GDP.

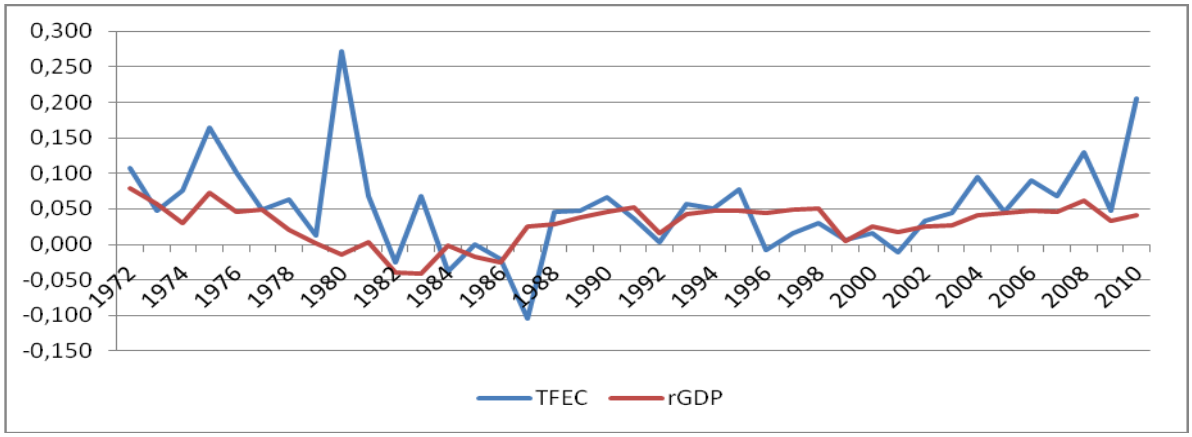

Fig. 1. Bolivia's Energy consumption and real GDP growth rates (1972-2010)

Source: Author using data from WDI.

Energy and Economic Profile of Bolivia

According to EIA 2012, Bolivia is among the poorest and least developed countries in South America. The World Bank classifies it as a low income country (World Bank 2012). Since the past twenty years, the average growth rate of Bolivia from 1998 to 2008 was 3.6%. For the last ten years however, this growth rate has been attributable to its export sector which added over 60% to the nation's GDP in 2006.

The country's GDP in 2009 was $17 billion, while the GDP per capita was $1758 (World Bank Indicator, 2012). Bolivia's GDP in terms of the purchasing power parity (PPP) equivalence and with inflation accounted for, increased by 11.3% between 1980 and 2009. Fig 1 shows the growth rates of Bolivia's total final energy consumption (TFEC) and real GDP (rGDP) from 1971 to 2010. The country's energy sector is vital to its economy and a significant source of natural gas within its region. Natural gas and other carbon minerals account for more than 6% of its GDP, 45% of its export and 30% of government revenue. Petroleum takes more than 50% of primary energy consumption while gas is responsible for most of the remainder. 15% of Bolivia's energy requirements are met by combustible renewables and waste (Fig. 2).

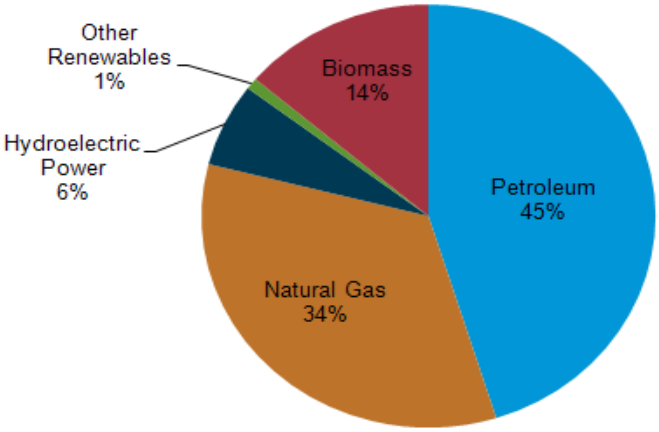

Fig. 2. Total energy consumption in Bolivia, by type, 2011

Source: EIA, 2012, Independent statistics and analysis.

Historically Bolivia was a net exporter of oil but with the sector's reorganisation, production of oil fell between 2007 and 2009 by about a quarter and it moved from a net exporter country status to a net importer of crude oil. Figure 2 indicates that there was a considerable rise in production at 2010, but it still had a production decrease. According to EIA 2012, Bolivia government officials say natural gas compensates for the shortfall in oil production. Bolivia trails behind Venezuela and Argentina in natural gas production.

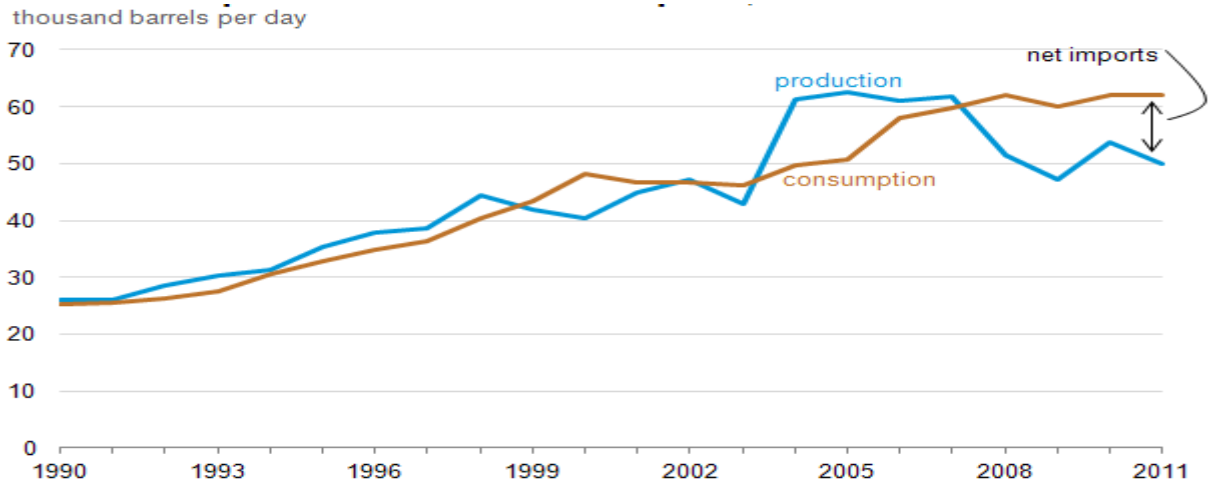

Fig. 3. Bolivia's oil production and consumption, 1990-2011

Source: EIA, 2012, Independent statistics and analysis.

Figure 4 shows that natural gas production rose since 1999. However a rise in its domestic gas market has resulted in its inability to meet contractual obligations to regional Brazil and Argentina. About one-fifth of its gas production has now been left to its domestic market with electricity demand responsible for more than 50% of gas consumption while industry and transportation are responsible for the remainder.

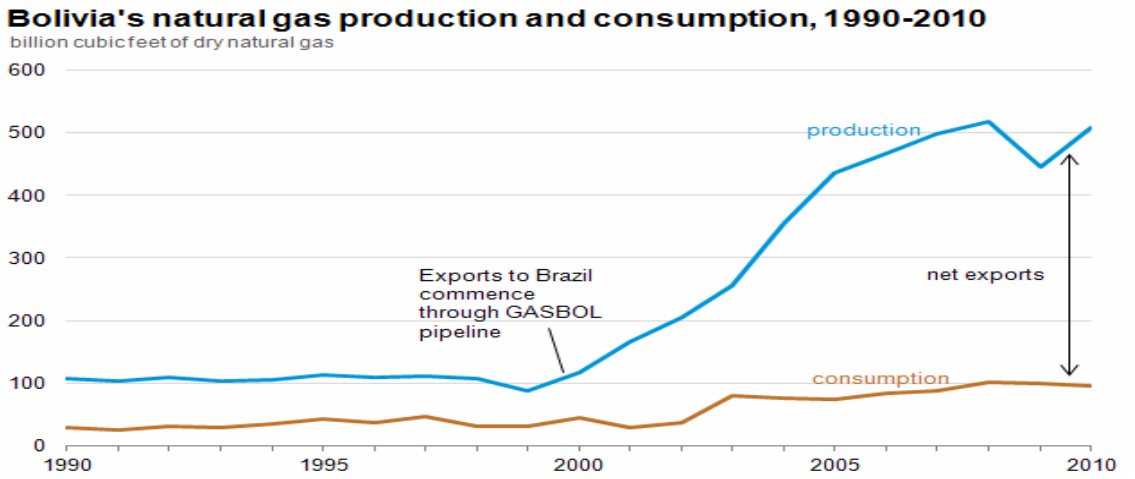

Fig. 4. Bolivia's natural gas production and consumption, 1990-2010

Source: EIA, 2012, Independent statistics and analysis.

Bolivia's Energy production started to decline recently from 2007 at a period when the country began to witness a rise in the total energy consumption. A close look at figure 4 indicates that oil and Natural gas accounted for more than three – quarter of this rise. As consumption rise faster about domestic supplies, there is no doubt that the resultant effect for Bolivia will be an increase in government expenditure for importing energy resources to meet domestic demand.

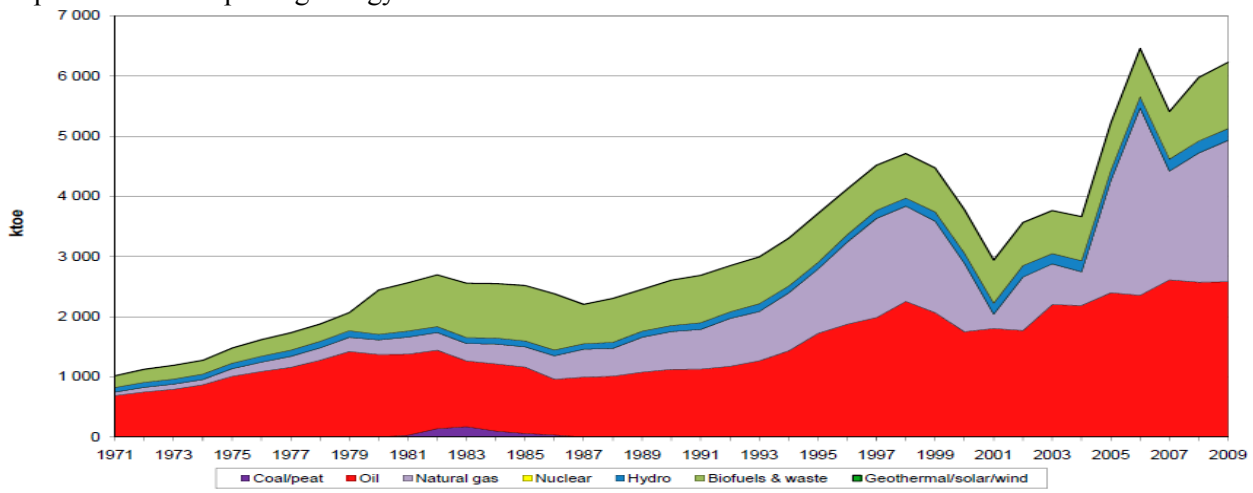

Fig. 5. Bolivia Total Primary Energy Supply

Source: IEA 2012 Energy Statistics.

Methodology. When considering the embedded relationship between energy consumption and economic growth in any economy, several issues deserve significant attention. First there are the country's energy use components at disaggregated level, the possibility of substituting one fuel for the other and the stage of economic development. Second there are the volume of economic activities, endowments of production factors and the consumption pattern of the populace. Only then the idea of a typical perfect model can be conceived. In the absence of these, it may be impossible for a model to exhaust all the possible interactions in the energy – economy relationship. Quite often, the methods and model employed by studies confines to the peculiar area of researcher's interest such that the models employed are specifically targeted at achieving the purpose of the investigation (Soile, 2012).

Tests Procedure

In order to accomplish this, the study employed the causality test relation put forward by Granger (1969) by specifying the model below to examine the nature of the causal relationships between our variables of interest. According to the model presumption, the time series property of a variable are perhaps the only relevant factors required to predict the behaviour of the said variable. This is as specified in the two regression equation below where all lower case Greek and Latin letters are used to represent fixed parameters while the time periods are proxy by the subscript (*i*) and (*t*) in the following equations.

$$Growth_t = \sum_{i=1}^{n} \alpha_i EneCon_{t-i} + \sum_{j=1}^{n} \beta_j Growth_{t-j} + \varepsilon_{1t} \dots\dots\dots\dots 1$$

$$EneCon_t = \sum_{i=1}^{n} \sigma_i EneCon_{t-i} + \sum_{j=1}^{n} \delta_j Growth_{t-j} + \varepsilon_{2t} \dots\dots\dots\dots 2$$

Where:

$\boldsymbol{\varepsilon_{1t}}and\boldsymbol{\varepsilon_{2t}}$ *represent the error term of the respective equation which are assumed to be serially uncorrelated with zero mean and constant variance.*

$\boldsymbol{Growth_t}$ *is the real GDP as proxy for economic growth in year t.*

$\boldsymbol{EneCon_t}$ *is a proxy for energy consumption measured as total final energy consumption in kilotons of oil equivalent in year t while all t, i and j stand for time periods.*

The Hypotheses:

In conducting the Granger test for causal link between two variables (i.e. *Growth and EneCon* in the above equations), the process is to estimate the two equations above under a hypothetical assumption that the present quantity of the $Growth_t$correlates with both the dated quantities of$Growth_{t-j}$ and $EneCon_{t-i}$ while the present level of $EneCon_t$ correlates with the past or dated values of $EneCon_{t-i}$and $Growth_{t-j}$. As a follow up to the assumption above, the main hypothesis that the study seeks to test can be stated in the Null form as below:

The Null Hypotheses:

- ✓ $Growth$ does not Granger Cause $EneCon$
- ✓ $EneCon$ does not Granger Cause $Growth$

What the Theory Expects

The decision to reject or not either of the above two null hypotheses in accordance with statistical theory underlying the Granger causality approach are crystal clear and direct in answering the main question of the study. First, the estimates from either equation have implication for the other. For instance, there can only be a case of *unidirectional causality without feedback* running from energy to growth not just when the estimated coefficient of the lagged quantities of $EneCon$ are statistically significant as a group in equation 1 but when in addition, the estimated coefficients of the lagged $Growth$ values in equation 2 are statistically insignificant. This is because if the sets of coefficients of $EneCon$ and $Growth$ appear statistically significant in the two equations, then a *bilateral causality* running both ways exist between the two variables inferring that both energy consumption and economic growth jointly affect each other. But then, in the case that the set of the lagged $EneCon$ coefficients are not statistically significant as a group in equation 1 and the sets of the lagged $Growth$ coefficients in equation 2 is statistically significant, an *unidirectional causality* that runs from economic growth to energy consumption exists. It is not in all cases that we will observe a defined interdependence between growth and energy. Hence, there will be *no causality* between the variable if for instance, the sets of coefficients of $Growth$ and $EneCon$ in equations 1 and 2 above are statistically insignificant.

The four major relationships that exist between energy consumption and economic growth are expressed statistically below using the parameter representations in equations 1 and 2 above.

If $\sum\alpha_i \neq 0$ in equation 1 and $\sum\delta_j = 0$ in equation 2; then a one way causality exists and runs from energy consumption to economic growth

If $\sum\alpha_i = 0$ in equation 1 and $\sum \delta_j \neq 0$ in equation 2; then the one way causality runs from economic growth to energy consumption

If $\sum\alpha_i = 0$ in equation 1 and $\sum\delta_j = 0$ in equation 2; then economic growth and energy are independent.

If $\sum\alpha_i \neq 0$ in equation 1 and $\sum\delta_j \neq 0$ in equation 2; then a two way causality exists and runs both ways from energy consumption to economic growth and vice versa.

Sources of Data

The study made use of secondary data sourced from both the World Development Indicator 2012 and the EIA energy balance, 2012. Both series were sourced through the ESDS database. The data on growth for the period of 1971 to 2010 i.e. constant GDP at 2000 U.S dollars were collected from the World Bank WDI. Data on total final consumption of all energy sources were obtained from the IEA non OECD energy balance 2012, for the same period of 40 years. The growth variable is inflation adjusted having been measured in constant dollars. The study tried both energy use measured in (kilotons of oil equivalent) and total final consumption. Both variables yielded similar results so the results involving the latter were reported below.

Results. The table below contained the outcome of the estimation results of the equation 1 and 2 in section 4.2 above. From the results, the sets of the lagged *EneCon* coefficients are not statistically significant as a group i.e. ($\sum\alpha_i = 0$) in equation 1 but the sets of the lagged *Growth* coefficients in equation 2 is statistically significant i.e. ($\sum \delta_j \neq 0$), which implies that an *unidirectional causality* that runs from economic growth to energy consumption exists. From table 1, the F-test statistics of 5.96 for the null hypothesis that *Growth* does not granger – cause *EneCon* is significant at all conventional levels (1%, 5% and 10%) and hence we reject the null and conclude that economic growth granger – cause energy consumption. These findings indicate that more energy is consumed as the economy achieve greater growth and not vice versa.

Table 1

Energy – Economy Causality results for Bolivia

Pairwise Granger Causality Tests			
Date: 01/21/13 Time: 20:26			
Sample: 1971 2010			
Lags: 2			
Null Hypothesis:	Observations	F-Statistic	Prob.
GROWTH does not Granger Cause ENECON	38	5.96487	0.0061
ENECON does not Granger Cause GROWTH		0.03871	0.9621

Source: E-views estimation Output, 2013.

Conclusion. Bolivia is not just a significant contributor to the Latin American Natural gas supplies, the country exports natural gas to both Brazil and Argentina. While the country's potential to be a significant fossil fuel producer and regional energy hub remain uncertain based on the actual size of Bolivia's proved natural gas reserves, the energy sector is of both economic and political significance. With the country's endowments of fossil fuel largely concentrated in the opposition dominated southern and the eastern region, continuous agitation for increased autonomy by these regions constitute a political threats to the energy future of Bolivia. Yet energy consumption continues to surge amidst thriving economy.

As it stands, Bolivia is faced with both energy supply and demand management policies. However, energy conservation and related demand management policy is not an option if energy is found to granger cause growth. To these end, the study investigates the interdependence between energy consumption and growth in Bolivia using the Granger causality approach proposed by Granger (1969). The results find evidence to reject the null hypothesis that economic growth does not granger-cause energy consumption in Bolivia which infers that an *unidirectional causality* that runs from economic growth to energy consumption exists. This implied that policies meant to manage the growing energy demand can be instituted without obstructing growth in Bolivia. In addition, the result indicates that Bolivian government can use energy pricing and taxes to raise revenue for additional revenue for economic development.

REFERENCES

1. LEE, C. Energy consumption and GDP in developing countries: a co-integrated panel analysis. In: Energy Economics. 2005, vol. 27, issue 3, may, pp. 415-427.
2. MALLICK, H. Examining the Linkage between Energy Consumption and Economic Growth in India. In: The Journal of Developing Areas. 2009, vol. 43, no 1, pp. 249-280.
3. NARAYAN, P.K., SMYTH, R. Energy consumption and real GDP in G7 countries: New evidence from panel cointegration with structural breaks. In: Energy Economics. 2008, vol. 30, pp. 2331-2341.
4. ODHIAMBO, N.M. Energy consumption, prices and economic growth in three SSA countries: a comparative study. In: Energy Policy. 2010, vol. 38 (5), pp. 2463-2469.
5. OH, W., LEE, K. Causal relationship between energy consumption and GDP revisited: the case of Korea 1970-1999. In: Energy Economics. 2004, vol. 26, issue 1, pp. 51-59.
6. SHIU, A., LAM, L.P. Electricity Consumption and Economic Growth in China. In: Energy Policy. 2004, vol. 32 (1), pp. 47-54.
7. SHYAMAL, P., BHATTACHARYA, R.N. Causality between energy consumption and economic growth in India: a note on conflicting results. In: Energy Economics. 2004, vol. 26, issue 6, pp. 977-983.
8. SOYTAS, U., SARI, R. Energy consumption and GDP: causality relationship in G-7 countries and emerging markets. In: Energy Economics. 2003, vol. 25, pp. 33-37.
9. STERN, D.I. A multivariate cointegration analysis of the role of energy in the US macroeconomy. In: Energy Economics. 2000, vol. 22, pp. 267-283.
10. YUAN, J., ZHAO, C. Electricity consumption and economic growth in China: Cointegration and co-feature analysis. In: Energy Economics. 2007, vol. 29 (6), pp. 1179-1191.
11. THE WORLD BANK. Bolivia [accesat 15 ianuarie 2016]. Disponibil: http://data.worldbank.org/country/bolivia?cid=DEC_SS_WBGDataEmail_EXT#cp_fin
12. IEA Energy Statistics [accesat 14 ianuarie 2016]. Disponibil: http://www.iea.org/stats/index.asp
13. POPESCU, M. Consolidarea parteneriatelor pentru o energie sigură durabilă şi competitivă = The consolidation of partnerships for sustainable competitive and secure energy. In: Economie şi Sociologie = Economy and Sociology. 2014, nr. 4, pp. 64-71.

Recommended for publication: 25.03.2016