World Review of Business Research
Vol. 1. No. 5. November 2011. Pp.28-37

The Relationship between Exports, Electricity Consumption and Economic Growth: Empirical evidence from Brazil

Janesh Sami* and Keshmeer Kanewar Makun**

The relationship between electricity consumption and economic growth has been intensively studied in energy economics. However, there are mixed evidence on the relationship, possibly due to omission of other relevant variables and low power of traditional cointegration tests in small samples. This paper examines the relationship between exports, electricity consumption and real income in an emerging market economy for the period 1971-2007. Employing bounds testing procedure, we find evidence of cointegration when real income is considered the dependent variable. In the long run, exports and electricity consumption have statistically significant and positive impact on economic growth.

Keywords: Exports, Electricity Consumption, Economic growth, Bounds testing procedure

JEL: Q43, C32

1. Introduction

The relationship between electricity consumption and gross domestic product has been investigated for many countries. To date, there is no consensus over the relationship. Many of these studies have examined the relationship ignoring other variables that can affect the relationship, thus resulting in omitted variable bias. In recent years, studies have included other variables such energy prices, employment. (Chang *et al* 2001, Govindaraju *et al* 2010, Masih and Masih1997, Narayan and Smyth 2005).

In this paper, we re-examine the relationship between electricity consumption and Gross Domestic Product (GDP) taking additional variable of exports. Specifically, we intend to find out if electricity consumption and GDP are cointegrated if exports are considered along. In doing so, we are able to avoid omitted variable bias to some extent, since exports can affect both GDP as well as electricity consumption. In addition, we wish to investigate if inclusion of exports can affect the long run relationship between electricity consumption and economic growth. We thus, investigate the existence of long run relationship between electricity consumption and GDP within a multivariate framework for an emerging market economy of Brazil. Our study, thus is believed to be more superior to numerous studies that examined the relationship between electricity consumption and economic growth within bivariate framework for fast growing economies, Yoo (2006) for Singapore, Thailand, Malaysia, Indonesia, Ghosh(2002) for India, Tang (2008) for Malaysia, Yoo and Kwak (2010). Briefly foreshadowing the main

*Janesh Sami (Corresponding Author), Lecturer in Economics, Department of Economics, Banking and Finance Fiji National University, Nasinu, Fiji, Email: janesh.sami@fnu.ac.fj or janesh.sami@gmail.com, TEL :(679)3684504
**Keshmeer Kanewar Makun, Lecturer in Economics, Department of Economics, Banking and Finance, Fiji National University, Nasinu, Fiji

results, we found that exports, electricity consumption and real income are cointegrated at 5% significance level. This result is thus, different from results obtained by Yoo and Kwak (2010) for Brazil.

Published data from World Bank (2011) shows the fluctuations in exports over the period (1960-2010).It seems that Brazil provides an interesting case of study, since it has experienced considerable fluctuations in its exports over the years; see (Figure 1.0).This raises the important question of, how this pattern of exports has altered the relationship between the relationship between electricity consumption and economic growth. We found evidence long run relationship between the three variables, suggesting that they share a common trend in the long run. The short run and long run impact of electricity consumption and exports on output is also estimated.

To establish cointegration, a new bounds testing procedure developed by Pesaran et al (2001) is applied. This method has several advantages over other estimators. Firstly, it can be applied regardless of order of integration. In other words, it does not require one to test for unit roots. Secondly, bounds testing procedure is well suited to small sample size. We rely on bound testing procedure to indicate which variable should be the dependent variable and we do not impose prior restriction.

The rest of the article is organized as follows: Section 2 provides an overview of literature on electricity consumption and economic growth. Section 3 discusses the data sources, while Section 4 explains the econometric methodology the empirical results and Section 5 concludes.

2. Literature Review

In past years, a large number of studies have examined the relationship between electricity consumption and real income. Recently, Payne (2010) surveys the literature on electricity consumption and economic growth and concluded that evidence on relationship between electricity consumption and economic growth is mixed. Smyth and Lean (2010a) examined the casual relationship between aggregate output, electricity consumption and exports for Malaysia and found evidence of bi-directional casuality between aggregate output and electricity consumption. Smyth and Lean (2010b) found evidence of uni-directional casuality running from economic growth to electricity consumption. Yoo and Kwak (2010) found evidence of long run relationship between electricity consumption and economic growth in Venezula and Columbia, but for Brazil, Argentina, Chile, Ecuador and Peru.

Francis *et al* (2010) found a long run relationship between electricity consumption and economic growth in Barbados. Chandran *et al* (2010) examined the relationship between electricity consumption and growth in Malaysia, including price. They found evidence of long run relationship between the variables. Smyth and Lean (2010c) applied Johansen Fisher panel cointegration test and found that there is a long run relationship between carbon dioxide emission, electricity consumption and output in ASEAN countries. Ciarreta and Zarraga (2010) applied panel data methodology to examine the long run relationship between economic growth and electricity consumption in 12 European countries. Their study included energy prices as an additional variable and found evidence that three series move together in the long run. Acaravi and Ozturk (2010) do not find evidence of

cointegration between electricity consumption per capita and real GDP per capita in 15 transition countries. Narayan and Smyth (2009) found positive effects of electricity consumption and exports on output in a panel of six Middle Eastern Countries.Abosedra et al(2009) found long run relationship between electricity consumption and real GDP. Odhiambo (2009) found that electricity, employment and economic growth are cointegrated in South Africa.Akinlo (2009) found evidence of long run relationship between electricity consumption and economic growth. Ghosh (2009) found that electricity supply, employment and real GDP in India are cointegrated .Narayan and Singh (2007) found that electricity consumption, employment and real GDP are cointegrated in Fiji. Ho and Siu (2007) found a long run relationship between electricity consumption and GDP for Hongkong. Mozumder and Marathe (2007) found that there is unidirectional causality from per capita GDP to per capita electricity consumption in Bangladesh. Tang (2008) studied the relationship between electricity consumption and economic growth in Malaysia and did not find any evidence of cointegration. Yoo (2006) also did not find any evidence of cointegration between electricity consumption and economic growth in ASEAN countries.Altinay and Karagol(2005) finds evidence of uni-directional casuality running from electricity consumption to GDP for Turkey. Lee and Chang (2005) found similar evidence for Taiwan. Narayan and Smyth (2005) found that electricity consumption, employment and real income are cointegrated. However, other studies have found evidence of unidirectional running from economic growth to electricity consumption. These include Ghosh (2002) for India, Hatemi and Irandoust (2005) for Sweden. Other studies have found evidence of uni-directional casuality running from electricity consumption. Shiu and Lam (2004) found that electricity consumption and economic growth in china are cointegrated. Yuan et al (2007) found that electricity consumption and economic growth are cointegrated. Wolde-Rufael (2006) found mixed evidence on casual relationship between electricity consumption and real GDP per capita. Squalli (2007) found evidence of long run relationship between electricity consumption and economic growth for all Organization of Petroleum Exporting Countries (OPEC) using bounds test. The author also found evidence of importance of electricity consumption for economic growth in Indonesia, Iran, Nigeria, Qatar and Venezuela. To best of our knowledge, there is no study that has examined between exports, economic growth and electricity consumption for Brazil.

3. Data

In order to examine cointegration, data were sourced from World Development Indicators (2010) and United Nations Statistics Division(2010). Electricity consumption (E)is measured in KWh. while exports(X) and real income are both measured in domestic currency. Prior to conducting any econometric analysis, all three variables were converted into natural logarithm to obtain elasticities. The sample period for the study is 1971-2007(thirty seven observations).

4. Empirical Methodology and Results

To investigate the existence of long run relationship between variables, bounds testing procedure developed by Pesaran *et al*(2001) is employed. There are two main steps in conducting bound test. In the very first step, we estimated the following unrestricted error correction model (UECM), in first difference form, along with one period

lagged of all variables in the model.

$$\Delta InY_t = \alpha + \varphi InY_{t-i} + \phi InE_{t-i} + \gamma InX_{t-i} + \sum_{i=1}^{\rho} \delta_i \Delta InY_{t-i} + \sum_{i=1}^{\rho} \beta_i \Delta InE_{t-i} + \sum_{i=1}^{\rho} \lambda_i \Delta InX_{t-i} + \varepsilon_t \quad (1)$$

Here In Y is real income, In E is electricity consumption and In X is exports. Δ is the first difference operator .The F-test for long run relationship involves testing the null hypothesis;

$$H_0 : \varphi = \gamma = \phi = 0$$

by testing the significance of the lagged levels of the variables using variable addition test option test in Microfit 4.0 The computed F-statistics is then, compared with critical values from Narayan (2005).If the computed F-statistics is greater than upper critical values reported in Narayan (2005), then, the null hypothesis of no cointegration can be rejected. If the computed F-statistics is lower than lower bound critical values, then null hypothesis of no cointegration cannot be rejected. The result for F-test for cointegration is shown in Table 1.0.An additional advantage of bounds test is that it indicates which variable should be normalized.

Table 1: F-Test for Cointegration

Dependent Variable	**Computed F-Statistics**					
In Y					4.571	
In E					3.677	
In X					1.221	
Critical Values from Narayan (2005)						
	99%		95%		90%	
	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
K=2	5.155	6.265	3.538	4.428	2.915	3.695

When we let real income be the dependent variable, our computed F-statistics is 4.57, which exceeds the 4.43 from Narayan (2005).We found evidence of cointegrating relationship between the three variables, when real income is considered the dependent variable at 5% significance level. The F-test also indicates that exports and electricity consumption can be treated as long run forcing variables. In other words, the bounds tests for cointegration suggest that we have a single cointegrating relationship between exports, electricity consumption and real income, when real income is treated as the dependent variable.

We are able to find evidence of long run relationship when export is included as an additional variable. Studies on other emerging economies by Ghosh (2009) found relationship between electricity supply, employment and real income. Our evidence on cointegration differs from Yoo and Kwak (2010)-for Brazil and Ghosh (2002) for India.Yuan *et al*(2006) and Shiu and Lam(2004), however, found cointegration between electricity consumption and economic growth for China within bivariate framework. Our studies suggest that it is important to include exports, when testing for long run economic relationship between electricity consumption and economic growth for fast growing economies. The study also indicates the aptness of bound testing procedure to test for cointegration between electricity consumption and growth .Mah (2000) has argued that Johansen cointegration test is reliable in small samples. We thus attribute lack of evidence

on the relationship on exclusion of exports and use of Johansen cointegration and Engle-Granger test (1987).

Since cointegration is found between the variables, the long and short run coefficients can be estimated easily. We then, estimated the long run coefficients of exports and electricity consumption, using equation (2).

$$InY_t = \alpha + \sum_{i=1}^{\rho} \eta InY_{t-i} + \sum_{i=1}^{\rho} \beta InE_{t-i} + \sum_{i=1}^{\rho} \delta InX_{t-i} + \varepsilon \qquad (2)$$

We used lag length of 3 .We view lag length as appropriate given sample size of our study. The estimated long run parameters are reported in Table 2.

Table 2: Estimated Long Run Coefficients Using the ARDL Approach

Dependent variable is InY_t			
Regressor	Coefficient	Standard Error	T-Ratio[Prob]
In E_t	0 .27534	0.14396	1.9127[.066] *
In X_t	0 .25969	0.11642	2.2306[.034] *
C	6.1496	0.70623	8.7077[.000]

Note:* indicates statistical significance at 5% level

Table 2 reports the long run elasticities of exports and electricity consumption. In line with our theoretical expectations, we find both exports and electricity consumption has positive impact on real income in the long run. Increase in electricity consumption in the long run by 1%, will be associated with 0.27% increase in economic growth, ceteris paribus.Also in the long run; increase in exports by 1% will lead to 0.25% increase in growth. Another interesting observation from Table 2 is that, the estimated effect of exports and electricity consumption on economic growth is quite close.

Table 3: Estimated Short Run Relationship (Dependent Variable Is $\Delta Inyt$)

Regresso	**Coefficient**	**Standard Error**	**T-Ratio[Prob]**
ΔIn E_t	0.52945	0.15421	3.4333[.002]**
Δ In E_{t-1}	0.40308	0.14644	2.7525[.010]**
Δ InX_t	0.075215	0.032433	2.3191[.028]*
ECM_{t-1}	-0.28963	0.11860	-2.4421[.021]

Note:* and ** indicates statistical significance at 5% level and 1% respectively.

Table 3 reports three important results. In the short run, the estimated effect of electricity consumption on real income is positive and statistically significant. In the short run,1% increase in electricity consumption will be associated with about 0.52% increase in real income. Secondly, exports also have positive impact on real income even in the short run. The estimated effect of exports on real income is statistically significant.Finally,We can also note the estimated coefficient of lagged ECM is statistically significant and estimated speed of adjustment is 28%.The statistical significant of this term supports our earlier conclusion that the three variables are cointegrated. The speed of adjustment is fairly low suggesting a slow progress to

solving disequilibrium in real income, following shocks to exports and electricity consumption.

Having estimated the short run relationship, we then proceed to test if the standard classical assumptions are satisfied and whether the estimated parameters are stable. Table 4 reports the major results from the different diagnostic tests that were conducted. To keep matters simple, only the computed p-values are reported.Lagrange multiplier test for serial correlation and Ramsey RESET test, Jarque-Bera and White tests were conducted to examine the major assumptions holds. The values in square brackets are the computed p-values and all of them are above 0.05, which suggest that none of assumptions have been violated.

Table 4: Diagnostic Tests

Serial Correlation = 0 .1667[.683]	Normality = 0.9989[.607]	Heteroscedasticity = 0.58012[.446]
Functional Form = 1.6303[.202]		

It was equally important to examine if the estimated parameters are stable throughout study period. We resort to CUSUM and CUSUM of Squares developed by Brown *et al*(1975) examine parameter stability. As one can note from Figure 2 and 3, the graphs do not indicate any major concern in regards to parameter instability or model misspecification. The plots indicated that estimated relationship is stable.

Figure 2: Plot of Cumulative Sum of Recursive Residuals

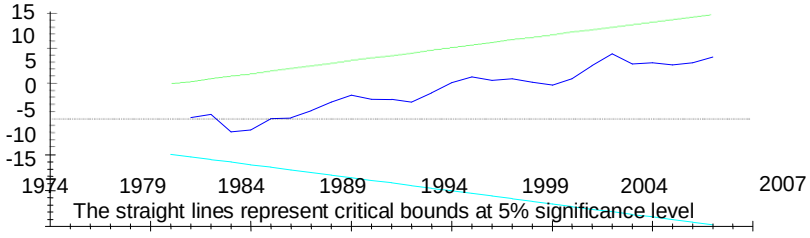
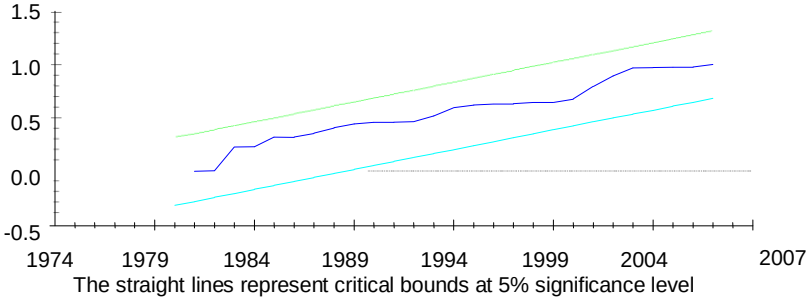


Figure 3: Plot of Cumulative Sum of Squares of Recursive Residuals



5. Conclusions and Policy Recommendations

This paper has examined the relationship between exports, electricity consumption and real income in Brazil. We applied bounds testing procedure and found evidence of cointegrating relationship between exports, electricity consumption and real income in this emerging market economy. Amongst our key results, we have found evidence that exports has positive impact on real income in the long run. This is supportive of the export-led growth hypothesis in Brazil. Being an emerging market economy, Brazil needs to further increase its exports in order increase its real income.

We have also established the importance of electricity consumption for economic growth. Electricity consumption has directly positive effects on economic growth. The government must invest heavily in energy infrastructure and devise better energy conservation techniques, support development of renewable energy and being careful at the same time that such effects do not have negative efforts on economic growth. One of limitation of this study, it has focused on Brazil only. We hope that this topic will be reinvestigated for other emerging economies. Future research could also extend the current body of knowledge on electricity consumption-GDP nexus by including adding variable such as labor, capital, and foreign direct investment. It is also possible for future researchers to examine the relationship between electricity consumption, GDP and exports in different industries.

Endnotes

We are grateful to anonymous reviewers for valuable comments and suggestion that helped improve the paper

References

Abosedra, SA & Ghosh, S 2008, 'Electricity Consumption and Economic Growth: The Case of Lebanon', *Applied Energy*, Vol. 86, pp, 429-432.

Acaravci, A & Ozturk, I 2010, 'Electricity Consumption-Growth Nexus: Evidence from Panel Data for Transition Countries', *Energy Economics*, Vol. 32, pp, 604-608.

Akinlo, AE 2009, 'Electricity Consumption and Economic Growth in Nigeria: Evidence from Cointegration and Co-feature Analysis', *Journal of Policy Modeling*, Vol, 31, pp, 681-693.

Altinay, G & Karagol, E 2005. 'Electricity consumption and economic growth: evidence from Turkey, *Energy Economics*', Vol. 27, pp. 849–856.

Chandran, VGR, Sharma, S, & Madhavan, K 2010. 'Electricity Consumption-Growth Nexus: The Case of Malaysia', *Energy Policy*, Vol. 38, pp. 606-612.

Chang, T, Fang, W, &Wen,LF 2001, 'Energy consumption, employment, output and temporal causality: evidence from Taiwan based on cointegration and error-correction modeling techniques', *Applied Economics,* Vol*.* 33,pp. 1045-1056

Chen, ST, Kuo, HI & Chen, CC 2007, 'The Relationship between GDP and Electricity Consumption in 10 Asian Countries', *Energy Policy*, Vol. 35, pp. 2611-2621.

Ciarreta, A & Zarraga, A 2010, 'Economic Growth-Electricity Consumption Causality in 12 European Countries: A Dynamic Panel Data Approach', *Energy Policy*, Vol. 38, pp. 3790-3796.

Ghosh, S 2002, 'Electricity Consumption and Economic Growth in India', *Energy Policy*, Vol. 30, pp. 125-129.

Ghosh, S 2009, 'Electricity Supply, Employment, and Real GDP in India: Evidence from Cointegration and Granger-Causality Tests', *Energy Policy*, Vol. 37, pp. 2926-2929.

Govindaraju C, Madhavan K, & Sharma S 2010, 'Electricity consumption-growth nexus: the case of Malaysia', *Energy Policy*, Vol. 38:pp. 606-12.

Ho, CY & Siu, KW 2007, 'A Dynamic Equilibrium of Electricity Consumption and GDP in Hong Kong: An Empirical Investigation', *Energy Policy*, Vol. 35, pp. 2507-2513.

Jumbe, CBL 2004, 'Cointegration and Causality between Electricity Consumption and GDP: Empirical Evidence from Malawi', *Energy Economics*, Vol. 26, pp. 61-68.

Lean, HH & Smyth, R 2010a, 'On the dynamics of aggregate output, electricity consumption and exports in Malaysia: Evidence from multivariate Granger casualty tests', *Applied Energy*, Vol. 87, pp. 1963-1971.

Lean, HH & Smyth, R 2010b, 'Multivariate Granger Casualty between electricity generation, exports, prices and GDP in Malaysia', *Energy*, Vol. 35, pp. 3640-3648.

Lean, HH & Smyth, R 2010c, 'CO2 Emissions, Electricity Consumption, and Output in ASEAN', *Applied Energy*, Vol. 87, pp. 1858-1864.

Lee, CC & Chang, CP 2005, 'Structural Breaks, Energy Consumption, and Economic Growth Revisited: Evidence from Taiwan', *Energy Economics*, Vol. 27, pp. 857-872.

Hatemi, A & Irandoust, M 2005, 'Energy consumption and economic growth in Sweden:
a leveraged bootstrap approach, 1965–2000', *International Journal of Applied Econometrics and Quantitative Studies* 2 (4), 87–98.

Francis, B, Lorde, T, & Waithe, K 2010, 'The importance of electrical energy for economic growth in Barbados', *Energy Economics* , Vol. 32, pp. 1411-1420

Morimoto, R & Hope 2004, "The Impact of Electricity Supply on Economic Growth in Sri Lanka", *Energy Economics*, Vol. 26, pp. 77-85.

Mozumder, P & Marathe, A 2007, 'Causality Relationship between Electricity Consumption and GDP in Bangladesh', *Energy Policy*, Vol. 35, pp. 395-402.

Narayan, PK & Smyth, R 2005, 'Electricity consumption, employment and real income in Australia: evidence from multivariate Granger causality tests', *Energy Policy* Vol. 33, pp. 1109–1116.

Narayan, PK & Singh, B 2007, "'The electricity consumption and GDP nexus for the Fiji Islands', Energy Economics Vol. 29, pp. 1141–1150.

Narayan, PK & Prasad, A 2008, 'Electricity Consumption-Real GDP Causality Nexus: Evidence from a Bootstrapped Causality Test for 30 OECD Countries', *Energy Policy*, Vol. 36, pp. 910-918.

Narayan, PK, &Smyth, R 2009, 'Multivariate Granger causality between electricity consumption, exports and GDP: evidence from a panel of Middle Eastern countries', *Energy Policy* Vol. 37, pp. 229–236.

Narayan, PK 2005a, 'The saving and investment nexus for China: evidence from cointegration tests', *Applied Economics*, Vol. 37(17), pp. 1,979–90.

Mah,JS 2000, "An empricial examination of the disaggregated import demand of Korea:the case of
information technology products',Journal of Asian Economics,Vol 11,pp.237-244

Mahadevan, R & Asafu-Adjaye, J 2007, 'Energy consumption, economic growth and prices: a reassessment using panel VECM for developed and developing countries', *Energy Policy* Vol. 35, pp. 2481–2490.

Masih, AMM & Masih, R 1997, 'on the temporal causal relationship between energy consumption, real income and price: some new evidence from Asian NICs based on a multivariate cointegration/vector error-correction approach', *Journal of Policy Modeling* Vol. 19, pp. 417–440.

Odhiambo, NM 2009, 'Electricity Consumption and Economic Growth in South Africa: A Trivariate Causality Test', *Energy Economics*, Vol. 3111, pp. 635-640.

Payne, JE 2010, 'A Survey of the Electricity Consumption-Growth Literature', *Applied Energy*, Vol. 87, pp. 723-731.

Pesaran, MH & Shin, Y 1999, 'An Autoregressive Distributed Lag Modelling Approach to Cointegration Analysis' *Econometrics and Economic Theory in the 20th Century: The Ragnar Frisch Centennial Symposium*, Cambridge University.

Pesaran, MH, Shin, Y & Smith, R 2001, 'Bounds Testing Approaches to the Analysis of Level Relationships', *Journal of Applied Econometrics*, Vol. 16, pp. 289-326.

Shiu, A & Lam, PL 2004, 'Electricity Consumption and Economic Growth in China', *Energy Policy*, Vol. 32, pp. 47-54.

Shiu, A & Lam, P 2004, 'Electricity consumption and economic growth in China', *Energy Policy*, Vol. 32, pp. 47–54.

Squalli, J 2007, 'Electricity Consumption and Economic Growth: Bounds and Causality Analyses of OPEC Countries', *Energy Economics*, Vol. 29, pp. 1192-1205.

Tang, CF 2008, 'A Re-examination of the Relationship between Electricity Consumption and Economic Growth in Malaysia', *Energy Policy*, Vol. 36, pp. 3077-3085.

Wolde-Rufael, Y 2006, 'Electricity Consumption and Economic Growth: A Time Series Experience for 17 African Countries', *Energy Policy*, Vol. 34, pp. 1106-1114.

Yoo, SH 2005, 'Electricity Consumption and Economic Growth: Evidence from Korea', Energy *Policy*, Vol. 33, pp. 1627-1632.

Yoo, SH 2006, 'The Causal Relationship between Electricity Consumption and Economic Growth in the ASEAN Countries', *Energy Policy*, Vol. 34, pp. 3573-3582.

Yoo, SH & Kwak, SY 2010, 'Electricity Consumption and Economic Growth in Seven South American Countries', *Energy Policy*, Vol. 38, pp. 181-188.

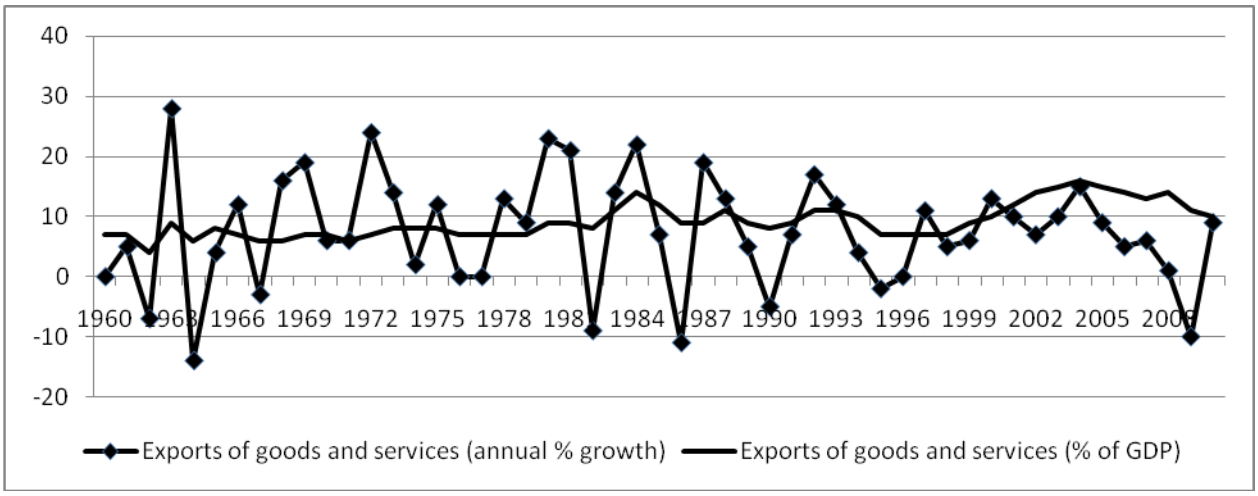
Yuan, JC, Zhao, S, Yu, & Hu, Z 2007, 'Electricity Consumption and Economic Growth in China: Cointegration and Co-feature Analysis', *Energy Economics*, Vol. 29, pp. 1179-1191.

Zamani, M 2007, ' Energy Consumption and Economic Activities in Iran', *Energy Economics*, Vol. 29, pp. 1135-1140.

Ziramba, E 2009, 'Disaggregate Energy Consumption and Industrial Production in South Africa', *Energy Policy*, Vol. 37, pp. 2214-2220.

Appendix

Figure 1.0: Trend in Exports for Brazil (1960-2010)



Source: World Development Indicators,(2011)