Electricity Consumption and Growth: Wavelet Analysis for Emerging Markets

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Abstract

This study approaches the highly debated topic on the relationship between electricity consumption and economic growth with a brand-new and strong analysis. In order to examine the comovement between electricity consumption and economic growth, wavelet analysis asserted by Rua (2010) is employed. The technique brings information about comovement not only for different frequency (revealing short run and long run distinction) but also overtime. The study focuses on emerging economies. The countries employed for the annual dataset of 1971-2011 are as follows: Argentina, Brazil, Chile, China, India, Indonesia, Korea, Mexico, Philippines, Singapore, Turkey and South Africa. The empirical findings suggest different results for each economy.

Keywords: *Electricity Consumption, Economic Growth, Emerging Markets*

JEL Classification: *O13, Q43, C22*

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Özet

Bu çalışmada, sıklıkla tartışılan elektrik tüketimi ve ekonomik büyüme arasındaki ilişkiye yeni ve güçlü bir analiz ile yaklaşılmaktadır. Elektrik tüketimi ve ekonomik büyümenin beraber hareket edip etmediğini incelemek için Rua (2010) tarafından sunulan dalgacık analizi kullanılmaktadır. Bu teknik, beraber hareket edip etmemeye ilişkin bilgiyi (uzun ve kısa dönem ayrımını ortaya çıkaran) farklı sıklıkların yanı sıra zaman içerisindeki harekete göre de vermektedir. Çalışmada yükselen piyasalara odaklanılmıştır. 1971-2011 arası yıllık veri seti için şu ülkeler incelenmiştir: Arjantin, Brezilya, Şili, Çin, Hindistan, Endonezya, G. Kore, Meksika, Filipinler, Singapur, Türkiye ve Güney Afrika. Ampirik bulgular, ülkeye göre sonuçların farklılaştığını göstermektedir.

Anahtar Kelimeler: *Elektrik Tüketimi, Ekonomik Büyüme, Yükselen Piyasalar*

JEL Sınıflandırmaları: *O13, Q43, C22*

1. Introduction

The relationship between electricity consumption and economic growth is debated heavily in the literature using several countries for different economies or economic groups. Demand for energy especially electricity is rising all over the world. Considering the growth potential of emerging economies, this demand is striking as observed in Figure 1. This study concentrates on the existence of a comovement between electricity consumption and economic growth for emerging countries. This is the first study to search for this relationship for emerging economies under wavelet methodology which a powerful technique to investigate comovement. Employing comprehensive techniques to examine the relationship is crucial since there is no consensus in the literature.

The discovery of electricity has contributed and still being contributing to the human civilization together with the need for energy. Civilization brings about dependency on energy as all production facilities, even in the house we live, require energy. However, many economies try to apply energy saving policies as with the cost that it brings. Electricity, the major energy source, requires energy production facilities such as nonrenewable energies like nuclear energy, natural gas, fossil fuel, coal, or renewable energies like solar or wind energies. Due to lack of finance, the necessary infrastructure and the know-how, emerging economies are in a way dependent on nonrenewable energies; moreover, having insufficient energy sources creates a further dependency on imported energy. Hence, such dependency justifies the electricity saving (conservation) policies. However, energy, being one of the basic factors of production, may render such policies erroneous if the aim is to allow the economy to reach its potential. Hence, investigating the existence of a comovement between the two series is crucial especially for emerging countries.

The study is structured as follows. The next section gives information regarding relevant empirical literature. Section 3 explains the underlying methodology. Section 4 describes the dataset and presents the empirical findings. Last section concludes the paper.

2. Literature

The literature on the relationship between electricity consumption and economic growth is broad. However, there is no consensus on the literature. Yet, different techniques bring about diverse results. The analyses used to investigate the relationship are short and long run comovement and causality. The findings vary from no relationship to uni-directional (one-way link) or bi-directional (two-way) causalities. Some of the relatively new studies are explained below with the distinction of analysis focusing on one economy or a group of countries.

Some of the studies that concentrate on the results from many samples are as follows. Lee and Chang (2007) find causal link from GDP to energy consumption for a sample comprised of 18 developing countries, moreover bidirectional causal link for a sample comprised of 22 developed countries. Al Iriani (2006), utilizing the period 1971–2002, observes a unidirectional causal link from GDP to energy consumption for a panel dataset on the six countries of the Gulf Cooperation Council. Ciarreta and Zarraga (2010), using annual data between 1970–2007 for 12 European countries, examine the long-run and causal relationship between electricity consumption and real GDP, including energy prices, under panel methodology. They find long run relationship and negative short run and strong causal link from electricity consumption to GDP. Lee (2005) argues that there exists causality from energy consumption to GDP utilizing a panel dataset of 18 developing countries for the period 1975–2001. Bildirici et al. (2012), investigating the causal link between electricity consumption and economic growth in per capita and aggregate levels using the auto regressive distributed lag (ARDL) methodology for some developed and developing countries, find diverse results for different economies. Wolde-Rufael (2014) under a bootstrap panel causality approach for the relationship between electricity consumption and economic growth for 15 transition economies for the period 1975–2010, find diverse causality links for different countries. Acaravci and Ozturk (2010) examine long-run relationship and causality issues between electricity consumption and economic growth in 15 transition countries using the Pedroni panel cointegration method for the period 1990–2006. They did not observe a long run relationship for the variables in equation. Yoo and Kwak (2010) examine the relationship for seven South American countries and obtains that results change from country to country with the findings of no causality, unidirectional or bi-directional causality. Belke et al. (2011) find bi-directional causal link between the two series for the analysis of 25 OECD countries.

There are also studies that employ dataset from a single economy. Altinay and Karagol (2005), regarding the relationship for Turkey for the period of 1950–2000, find strong evidence for unidirectional causality running from the electricity consumption to the income. Mazbahul and Nazrul (2011), using vector error correction model for the period 1971–2008 for Bangladesh, find long-run bi-directional causality between electricity consumption and GDP per capita. Yoo (2005) examine short and long-run causal relationship between electricity consumption and economic growth for Korea utilizing cointegration analysis and error correction models and observes that there is a bi-directional causality.

3. Methodology: Wavelet-Based Measure of Comovement

Comovement techniques are highly dominant analyses in econometrics. Traditionally comovement analysis is directed towards time domain with the most well-known analysis as correlation coefficient. This traditional technique brings only one value for the degree of comovement. However, this value may change over time. Under such a reality, computations regarding a rolling window correlation coefficient or considering non-overlapping sample periods has become a new method to take into account of the differentiation in the degree of comovement. Another method to consider the differentiation in the correlation is the frequency domain analysis. Using the underlying Fourier analysis, one can obtain degree of comovements under different frequency levels. For instance, Croux et al. (2001) propose an analysis to measure comovement in the frequency domain. On the hand, this analysis does not include the situation that degree of comovement may change over time. The wavelet method asserted by Rua (2010), combines both the comovement at the frequency level and over time at the same time. The degree of comovement ranges between -1 and 1. In the analysis, high frequency brings information about short run and low frequency brings information about long run.

4. Data and Empirical Findings

The dataset is obtained from World Bank. Electric power consumption (EC) is of kWh per capita and GDP growth rates (%) are annual variables between the period 1971-2011. The economies employed are Argentina (ARG), Brazil (BRA), Chile (CHL), China (CHN), India (IND), Indonesia (INDO), Korea (KOR), Mexico (MEX), Philippines (PHI), Singapore (SIN), Turkey (TUR) and South Africa (ZAF). The descriptive statistics for electric consumption and growth rates are given in Tables 1 and 2. The figures 1 and 2 reflect time series for both variables. All computations are done using Matlab.

Table 1: Descriptive Statistics for Electricity Consumption

	ARG	BRA	CHL	CHN	IND	INDO	KOR	MEX	PHI	SIN	TUR	ZAF
Mean	1645.9	1446.6	1742.2	888.8	301.7	240.1	3668.7	1265.4	417.2	5097.4	1152.9	4091.0
Med.	1410.7	1481.3	1317.7	548.9	288.4	180.7	2588.8	1260.4	360.7	5104.8	964.1	4365.5
Max.	2967.4	2438.0	3568.1	3298.0	684.1	679.7	10162.0	2091.7	647.0	8520.0	2709.3	5061.2
Min.	870.5	455.5	742.8	151.2	97.8	14.5	295.6	492.7	235.8	1154.8	247.1	2246.1
St.D.	594.4	549.5	958.2	838.7	165.1	208.4	3112.0	465.0	114.3	2528.8	721.9	764.7
Skew.	0.7	-0.1	0.6	1.4	0.6	0.6	0.7	0.0	0.6	0.0	0.6	-1.1
Kurt.	2.4	2.1	1.8	4.0	2.4	2.0	2.0	1.8	2.0	1.5	2.1	3.0
J.B.	4.1	1.6	4.9	15.3	2.8	4.0	4.5	2.5	4.1	3.7	3.6	8.0
Prob.	0.1	0.4	0.1	0.0	0.2	0.1	0.1	0.3	0.1	0.2	0.2	0.0
Obs.	41	41	41	41	41	41	41	41	41	41	41	41

Table 2: Descriptive Statistics for Growth Rate

	ARG	BRA	CHL	CHN	IND	INDO	KOR	MEX	PHIL	SIN	TUR	ZAF
Mean	2.74	4.06	4.37	9.15	5.48	6.00	7.37	3.52	3.84	7.46	4.39	2.58
Med.	3.85	3.96	5.60	9.21	5.71	6.36	7.43	4.06	4.41	8.29	5.27	3.01
Max.	12.67	13.98	12.28	15.18	10.26	9.78	14.79	9.70	8.92	15.24	10.46	6.62
Min.	-10.89	-4.39	-11.36	-1.60	-5.24	-13.13	-5.71	-5.76	-7.32	-2.23	-5.70	-2.14
St.D.	5.96	4.16	5.04	3.42	3.15	3.68	4.05	3.69	3.32	3.99	4.26	2.32
Skew.	-0.38	0.15	-1.45	-0.79	-0.99	-3.56	-0.91	-0.71	-1.79	-0.77	-0.85	-0.42
Kurt.	2.18	2.97	5.22	4.15	4.63	18.95	4.49	3.39	7.12	3.23	2.86	2.28
J.B.	2.15	0.15	22.76	6.49	11.21	521.17	9.44	3.74	50.90	4.10	4.93	2.08
Prob.	0.34	0.93	0.00	0.04	0.00	0.00	0.01	0.15	0.00	0.13	0.09	0.35
Obs.	41	41	41	41	41	41	41	41	41	41	41	41

The threshold level to suggest significant comovement is selected to be 80%. The values below are of no concern for the interpretation. Argentina and Mexico, as can be seen with the dark gray cycles, reflect positive comovement between the series after 2000s at low frequency, i.e., long run. Brazil reflects positive comovement in low frequencies after 1990, whereas negative comovements are observed up to the end of 1970s at both low and high frequencies. Chile reflects positive correlation after 1990s at low frequencies. For China and Philippines, there is no significant comovement. India reflects positive correlation at relatively higher frequencies. For Indonesia, there is significant positive comovement between 1990-1995 at low frequency. Singapore shows positive correlation at relatively lower frequencies after 1990s whereas there are significant negative correlations at higher frequencies. Turkey and South Africa reflect highly significant positive comovements at low frequencies after 1990s. Differently from the other countries, Korea reflects a negative comovement at very high frequencies over all data period.

5. Conclusion

This paper examines the relationship between electricity consumption and GDP growth for a group of emerging countries under the fact that these countries have high potential growth but are insufficient in financing energy and therefore, their growth may be fragile due to this dependency. Hence, the existence of comovement is investigated to scrutinize this dependency. To examine the existence of comovement, a new analysis suggested by Rua (2010) is employed which takes into account of the over time changes in comovements and at different frequency levels.

The empirical findings obtained from wavelet based measure of comovement suggest diverse findings for each economy. Except for Korea, China and Philippines, all economies suggest positive comovement but at different frequencies of at different time periods. The negative comovement obtained from Korea may be attributed to the high saving ratios of the economy and that together with the growth in income, households (not firms) may be lowering their energy consumption; or that lower energy consumption may be boosting economic growth due to the decline in the dependency on energy sources. China and Philippines do not reflect any comovement between the two series. No comovement may infer that there is no need to abstain from energy conservation policies for these economies.

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Appendix

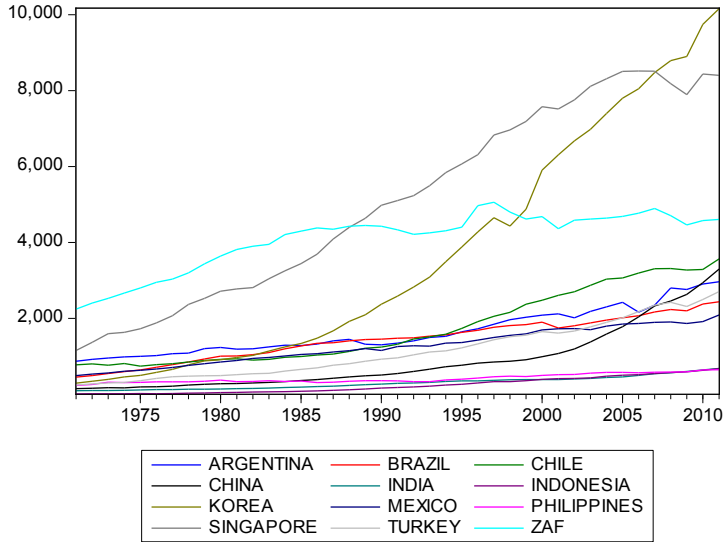*Figure 1: Electricity Consumption Per Capita of Selected Emerging Countries*
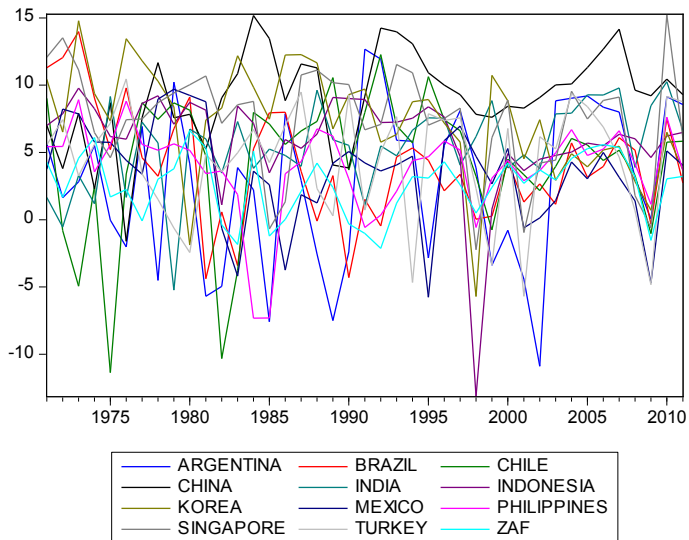

Figure 2: GDP Growth Rate of Selected Emerging Countries

Figure 3: Wavelet Based Comovement Analyses

ARG-Electricity Consumption-GDP Growth Rate

BRA-Electricity Consumption-GDP Growth Rate

CHL-Electricity Consumption-GDP Growth Rate

CHN-Electricity Consumption-GDP Growth Rate

IND-Electricity Consumption-GDP Growth Rate

INDO-Electricity Consumption-GDP Growth Rate

KOR-Electricity Consumption-GDP Growth Rate

MEX-Electricity Consumption-GDP Growth Rate

PHI-Electricity Consumption-GDP Growth Rate

SIN-Electricity Consumption-GDP Growth Rate

TUR-Electricity Consumption-GDP Growth Rate

ZAF-Electricity Consumption-GDP Growth Rate