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CONTENTS

CO-MOVEMENT OF ELECTRIC POWER CONSUMPTION AND INDUSTRIAL GROWTH IN EMERGING ECONOMIES

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Abstract

This paper investigates the co-movement of electric power consumption and industrial growth in a panel of 17 top emerging countries between 1975 and 2016. The FMOLS shows a long-run relationship and that industrial growth is elastic to gross capital formation but not elastic to electricity. However, causality results support the feedback hypothesis that industry and electric power consumption are mutually dependent for the emerging countries. Moreover, electricity and capital formation are mutually dependent and since capital formation has more impact on industries, it suggest that shortage of electricity could lead to fall in capital formation and slowed industrial growth. Hence there is the need to emphasize the importance of a renewable energy policy which will enhance the electricity supply as these economies gear towards extensive industrialization.

Keywords: Electricity consumption, industry value added.
JEL classification codes: O13, O47, Q43.

1. INTRODUCTION

Energy is an indispensable force of economic development, extensive use of the energy based inputs in production processes has strong implications for emerging market economies (Rybczynski: 1976). This is because emerging economies witness some development processes, rapid expansion in economic activities, rapid industrialization, rising population and rapid urbanization which require huge consumption of energy. The changes in the energy industry coupled with change in technology, environmental factors, instability in oil prices for some years and a call for cleaner energy diverts the quest for energy from the level of coal and petroleum products to the search for cleaner energy such as electricity.

While electricity consumption is being transmitted into industrial activities, the elasticity of output with respect to electricity consumption depends a number of factors: First, where there are alternatives to electricity, its use may not be so important in industry because of the availability of alternative sources of energy. Second, if the share of electricity cost in production is relatively low, increase in access to electricity leads to a further fall in production costs, this will motivate more energy intensive industries to spring up, and more electricity will in turn be required. Third, where the productions are not energy intensive, generally the use of electricity may not be significant in the industries. If production is energy intensive and electricity is a major source of energy, investment and output may be low if access to electricity is low, this makes producers to substitute less energy intensive methods of production for more energy-intensive methods, thus, less electricity will be consumed. In the quest for more development, substitution effect may cause some industries to use more of alternative energy sources which are not clean, then, the problem of carbon emissions arises. The magnitude of low consumption effect, gets seemingly stronger and is more likely to be sustained.

Economic prosperity tend to motivate electricity consumption per capita (Sadorsky, 2009). Therefore, as their economies grow larger, the emerging economies may experience energy security issues and adequate energy supply challenge. Given this sensitive nature and the general economic benefits of electricity to emerging economies, an analysis of the co-movement between industrial growth and electricity consumption becomes necessary in this study as it investigates if the industrial growth in top 17 emerging economies is being led by a renewable energy, electricity for the period 1990-2016.

There are two main contributions of this study: first, it seeks to find out if the growing industries and capital formation of emerging countries are energy-led via electricity; second, it confirms the percentage of industry's dependence on electricity and capital formation. This becomes important for policy maker to note that suppress the prospects of their industrial growth is dependent on the strength of their energy sector. If properly harnessed, their industrial growth can be sustained through renewable energy policy that allows more electricity use with less environmental challenge to combat with. The major variable of interest is electric power consumption per capita as a determinant of industry (using the value added of industry as proxy for industrial growth) and while gross capital formation is included in the multivariate model as major determinant of industrial output.

2. LITERATURE REVIEW

The hypotheses of the electricity consumption and economic growth relationship has been categorized into four: (1) growth hypothesis which assumes that electricity is a necessity for economic growth, this is affirmed when a causality runs from electricity to economic growth; (2) conservation hypothesis which assumes that an economy is less energy-dependent, this is affirmed when causality runs from economic growth to electricity consumption; (3) feedback hypothesis which assumes that electricity consumption and economic growth are mutually dependent, this is affirmed when there is a bidirectional causality between both; and (4) neutrality hypothesis which assumes there is no causal link between both and this is affirmed when there is no causality running from either of both to another (Masih and Masih, 1998; Karanfil and Li, 2015; Apergis and Payne, 2009). The pioneer article of Kraft and Kraft (1978) used the Sims techniques and favoured the conservation hypothesis but does not favour the reverse of this hypothesis. Some estimations which used different techniques on different time periods have also supported this hypothesis, while some have succeeded the study of Akarca and Long (1980) to oppose the findings. A number of studies examined the relation between energy consumption and economic growth and electricity consumption and economic growth, while some employed a multivariate model some examined a bivariate model but with divers results.

A bivariate time series model of Altinay and Karagol (2004) did not find causality between energy consumption and economic growth. Asafu-Adjaye (2000) and Yoo (2006), despite using the same techniques, found different results for four different countries. Akinlo (2009) found cointegration between real GDP and electricity consumption. Lin and Liu (2016) confirms that electric power industry is the key to economic development of an emerging economy. All these used time series analysis, results may have been influenced by short data span which lowers the power of cointegration test but panel analysis has ability to account for heterogeneity cross sections and time, and its ability to model dynamic complex behavioral models.

In panel analyses of bivariate models, Lee (2005) showed a clear support for a long-run relationship and unidirectional causality from energy consumption to GDP. On the other hand, Masih and Masih (1998) and Mehrara (2007) show a unidirectional causality otherwise. Soytas and Sari (2003), Oh and Lee (2004) and Lee and Chang (2007) found a bidirectional causality in bivariate models of energy consumption and economic growth. While including other relevant variables is expected to address the problem of omitted variable and yield better causality and cointegrating relations (Stern (2000), Karanfi (2009) and Kim (2015), Stern (1993) did not find evidence of causality but Lee and Chang (2008), Apergis and Payne (2009), Narayan and Smyth (2008) and Salahuddin and Alam (2016) found cointegration and causality in their bivariate panel models. Hossain (2011) included three additional variables, results showed evidence of cointegration but the Granger causality results did not show long-run causal relationship. For energy exporters, there is a long run and short run bidirectional causality between energy consumption and economic growth (Apergis and Payne, 2010; Mahadevan and Asafu-Adjaye, 2007), and between output growth and energy use (Ghali and El-Sakka, 2004).

Zhang and Cheng (2009) suggest that growth is responsible for energy consumption and carbon emissions in the long run, and a bidirectional causality has been established between CO2 emissions and economic growth (Wang, et al. (2011), in order to overcome these problems, other sources of clean energy are being pursued and a number of studies also showed that electricity consumption and economic growth have some long run and short run relationships.

On the relationship between electricity consumption and economic growth, Gachino, and Hoque (2016) and Magnani and Vaona (2016) found a long-run equilibrium relationship. Sarwar, Chen and Waheed (2017) confirmed bidirectional relationships between electricity consumption and GDP, and between electricity consumption and fixed capital formation in a panel analysis. Wolde-Rufael (2014), with bootstrap panel Granger causality showed results for 15 transition economies, a bidirectional causality runs in one, unidirectional causality runs from electricity consumption to economic growth in two, and otherwise in three, while, the rest have no causality in any direction. Bah and Azam (2017) found no causality between electricity consumption and economic growth in a time series analysis for South Africa.

In Saudi Arabia, Mezghani and Haddad (2017) showed that shocks to electricity consumption can be traced to economic growth and vice versa while economic growth is raises the consumption of electricity in China (Ge et al., 2017) and Zhang et al., 2017). Salahuddin and Alam (2015) applied an ARDL bounds test for cointegration and Granger causality tests indicate that the internet use and economic growth stimulate electricity consumption and there is no significant short-run relationship with electricity consumption but a unidirectional causal link running from internet usage to economic growth and electricity consumption. Real GDP per capita and hydroelectricity consumption per capita are cointegrated in Apergis, et al. (2016). Khan and Abbas (2016) reveal that electricity demand is more responsive to changes in income than changes in prices at the aggregate and disaggregate levels.

Though, the disparity in empirical findings often comes from the differences in the estimation techniques and variables used, these findings do not differ totally from the previous time series study as they showed various results depending of the variables used, and while some have shown that renewable energy can lead to more growth, some have declined from the hypothesis.

3. METHODOLOGY AND RESULTS

The study uses annual time series data for 17 emerging countries all gotten from the 2017 World DataBank. Countries include Bangladesh, Brazil, Chile, China, Colombia, India, Indonesia, Iran, Malaysia, Mexico, Nigeria, Pakistan, the Philippines, Russia, South Africa, South Korea, United Arab Emirates, Turkey and Vietnam. The countries and period chosen, 1990 to 2016, were based on data availability. Electric power consumption is measured in kWh per capita, Gross fixed capital formation is the percentage of GDP and Industry, value added measured as a percentage of GDP all used in natural logarithms. Graphic representations of these variables for the individual countries in the panel is shown in figures 1-3 below.

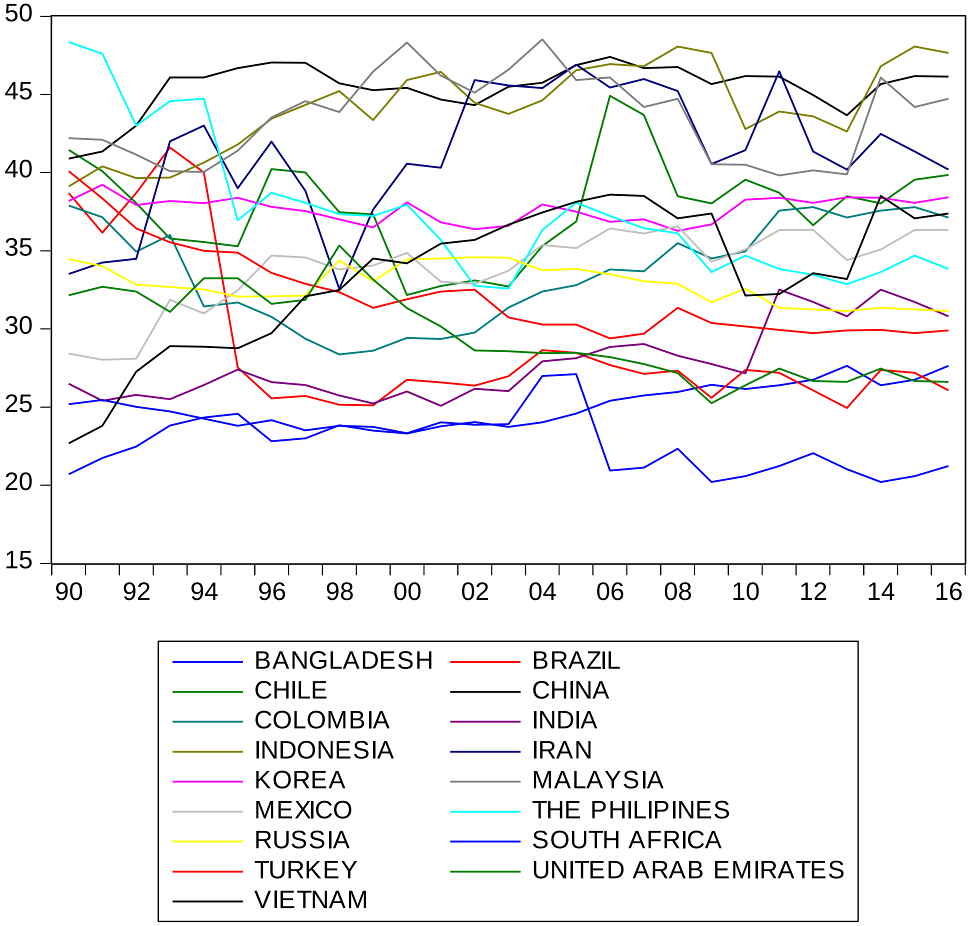

Figure 1. *Trends in the value added to industry in emerging countries between 1990 and 2016*

Source: The World Development Indicators Database, The World Bank (2017).

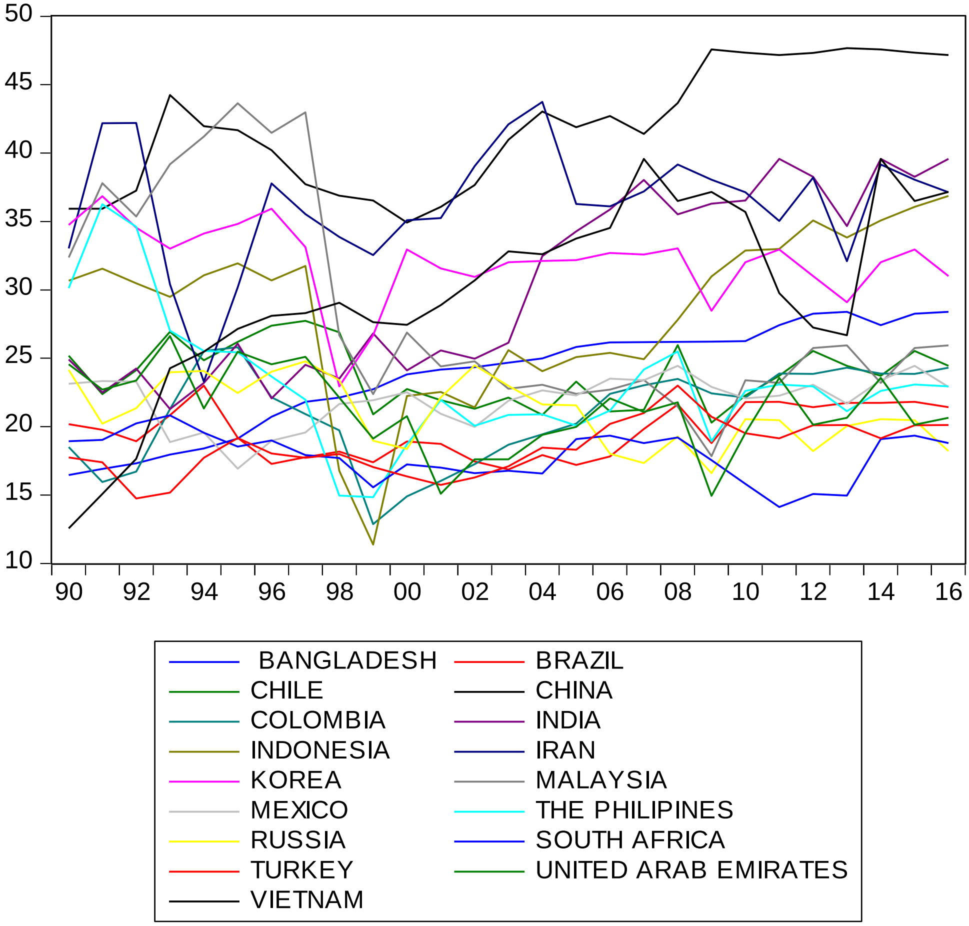

Figure 2. *Trends in Gross Capital Formation in emerging countries between 1990 and 2016*

Source: The World Development Indicators Database, The World Bank (2015).

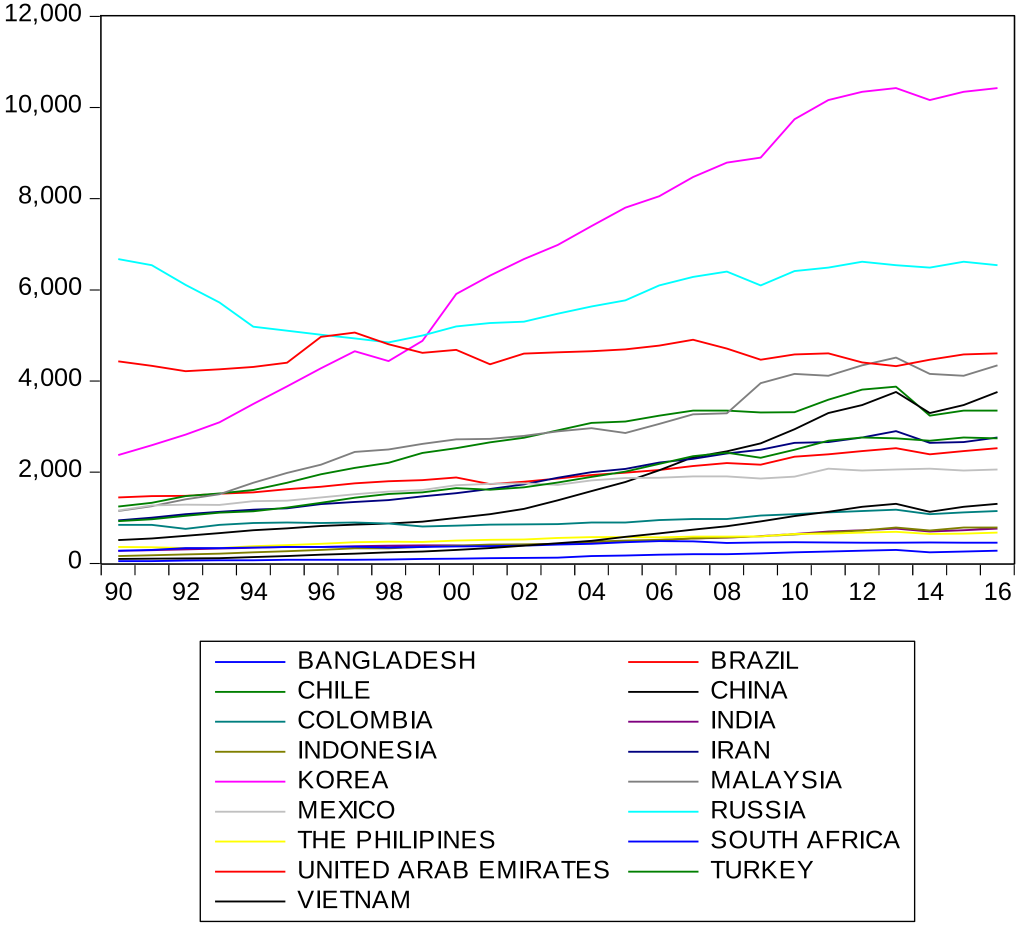

Figure 3 Trends in Electric Power Consumption in emerging countries between 1990 and 2016.

Source: The World Development Indicators Database, The World Bank (2015).

Model:

$lnIVA = f\,(lnGCF, lnEPC)$

$lnIVA_{it} = \beta_0 + \beta_1 lnGCF_{it} + \beta_2\, lnEPC_{it}$

*ln*IVA is the log of value added of industries, *ln*GCF is the log of gross capital formation and *ln*EPC is the log of electric power consumption per capita.

Table 1. *Unit root tests with constant terms and trends*

Variables	LLC statistics		IPS statistics		Fisher ADF statistics		Fisher PP statistics	
	Levels	First Difference	Levels	First Difference	Levels	First Difference	Levels	First Difference
LIVA	-0.66332	-2.46663***	0.96384	-4.31398***	21.5891	67.7817***	28.7060	515.475***
LGCF	-0.34043	-1.94054***	-0.62127	-4.58063***	33.8121	70.4740***	35.8824	272.530***
LEPC	0.47718	-1.67479**	1.59286	-2.29090**	20.2402	48.4198	19.1146	163.923***

Notes: (1) *** denotes 1% significance and ** denotes 5% significance.

Table 2. *Fully Modified Least Squares (FMOLS), LIVA as the dependent variable*

Variable	Coefficient	Standard Error	t-Statistic
LGCF	0.145073***	0.025456	5.698925
LEPC	0.036448***	0.011103	3.282632

Note: *** denotes 1% significance.

Table 1 shows the panel unit root results of Choi (2001), Levin et al. (2002), Im et al. (2003) and Madala and WU, the model was estimated with individual intercept and trend. All three variables were not stationary at level, but are integrated of order one, that is I(1), in this case it is necessary to test if the linear combination of these variables will be in equilibrium in the long run. The FMOLS test and cointegration tests examines the existence of a long-run relationship between them variables.

The FMOLS result is reported in Table 2, they are the parameter estimates of heterogeneous long run coefficients, and are therefore, interpreted as long-run elasticities. Both independent variables have positive signs to show that they have positive impact on value added to industry, but the dependent variable, LIVA is more elastic to gross capital formation with an elasticity of about 0.14 while electric power consumption shows an elasticity of 0.04. This means that a percentage increase in electric power consumption per capita will increase value added to industry by about 0.036% and a percentage increase in gross capital formation increases the value added to industry by 0.14%. These results are highly significant at 1% each.

The implication of this is that electricity consumption is important in meeting the needs of economic growth of the examined emerging market economies, however, gross capital formation is more important.

Table 3. *Pedroni Residual Cointegration Test*

	Within dimension		Weighted statistic	
Test	Statistics	Prob.	Statistics	Prob.
Panel v-statistic	-0.151548	0.5602	-0.393277	0.6529
Panel rho-statistic	-0.578601	0.2814	-0.793123	0.2139
Panel PP-statistic	-2.091078**	0.0183	-2.244916**	0.0124
Panel ADF-statistic	-2.913579**	0.0018	-2.853587***	0.0022
	Between dimension			
Group rho-statistic	1.022685	0.8468		
Group PP-statistic	-1.435683**	0.0755		
Group ADF-statistic	-3.063280***	0.0011		

Note: ***denotes 1% level of significance and ** denotes 5% level of significance

Table 4. *Kao Residual Cointegration Test*

ADF t-Statistic	Prob.
-3.416945***	0.0003

Note: ***denotes 1% level of significance.

The cointegration tests results also show that there is a relationship between these variables. Table 3 reports the Pedroni panel cointegration estimates. Six out of eleven statistics significantly reject the null hypothesis of no cointegration, it can thus be concluded that the there is a long run co-movement between lIVA, lEPC, and lGCF. Because of the multivariate model being examined, we decide to examine the model with the Kao residual cointeration tests. Results in Table 4 also validates the rejection of the null hypothesis of no cointegration at 1%. This implies that Industry Value Added, Electric Power Consumption and Gross Capital formation will move together in the long run, hence we proceed to examine the direction of these relationships.

Table 5. *Pairwise Granger Causality Tests*

Dependent variable	Sources of causation		
	ΔLIVA	ΔLGCF	ΔLEPC
ΔLIVA	-	3.75367**	2.34790**
ΔLGCF	1.62058	-	4.28177**
ΔLEPC	5.46482***	6.37528***	-

Note: ***and **denote 1%, and 5% levels of significance respectively.

Due to non-stationarity of the variables in their natural forms, we differenced them so that we can apply the Pairwise Granger causality which considers fixed coefficients. Results are reported in Table 5 showing bidirectional causal relationships between electric power consumption and industry value added, and between electric power consumption and gross capital formation. This implies that electric power consumption helps to predict the future value added to industry and gross capital formation. In the same vein, both value added to industry and gross capital formation are able to predict electricity consumption for these emerging economies. However, a causal relationship runs from gross capital formation to industry value added and no causality otherwise. Industry value added does not matter for gross capital formation, but capital formation is important in predicting the value added to industry for the emerging market economies. Overall evidence shows the existing interaction between electricity consumption and economic growth.

4. CONCLUSION

It is necessary for emerging economies to design an effective renewable energy policy for their industries, hence, there is a need to understand the relationship between electric power consumption and industrial growth for their set of countries. These data show that there is a long run equilibrium relationship between industrial growth, electricity consumption, and gross capital formation.

The estimation of the FMOLS indicates that industrial growth is more elastic to gross capital formation and while elasticity to electricity is as low as 0.04 %. However, Granger-causality runs from electric power consumption and gross capital formation to industry while a reverse causality only runs from industry to electric power consumption. This supports the feedback hypothesis that industry and electricity are mutually dependent for the emerging countries. The positive response of industries to both variables suggests that they both play an important role in the transition process and co-move in the long run. Moreover, capital formation has more effect on industries, and electricity and capital formation are mutually dependent. Attempt to reduce electricity consumption could lead to fall in capital formation and slowed industrial growth. This stresses the importance of integrating electricity into the renewable energy policy to enhance the electricity supply as these economies gear towards extensive industrialization.

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