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Electric power consumption, foreign direct investment and economic growth

A comparative study of India and Pakistan

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Abstract

Purpose – The purpose of this paper is to find potential causality and comparative relationships between electric power consumption, foreign direct investment and economic growth for India and Pakistan.

Design/methodology/approach – Granger causality tests have been employed for estimating the short and long run relationships between the variables, along with the adoption of co-integration and error correction mechanism.

Findings – Empirical evidence for India covering a period of 1975-2008 indicates long run causalities for electric power consumption and foreign direct investment boosting economic growth, electric power consumption and economic growth impacting foreign direct investment. For Pakistan, causality was established for foreign direct investment and economic growth inducing electric power consumption in the long run.

Practical implications – For India, there is a strong need of policy that would guarantee secure and continued supply of electricity, as enhanced electric consumption is expected to boost foreign direct investment and economic growth. Pakistan should aim for cost-effective, stable and environment friendly alternate to fossil fuels as the main source of its electric power generation.

Originality/value – Literature on the electricity consumption-FDI-economic growth nexus is scarce. The present study adds to this strand of literature. Also for the first time, in this scenario, this paper uses two economies (India and Pakistan), provides a comparative analysis of the empirical results and presents prospective explanations for the observed causality differences between the two economies.

Keywords India, Pakistan, National economy, Economic growth, International investments, Electric power consumption, Foreign direct investment, Energy economics

Paper type Research paper

1. Introduction

Studies on economic growth and its determinants are abundant in literature. Researchers have established various determinants of the economic growth and have tried to establish relationships between these determinants and growth. Energy consumption tends to define the growth capabilities of an economy; greater the utilization of energy, more will be the growth and enhanced will be the overall development of the economy. Existing literature on growth-energy consumption (or growth-electricity consumption) nexus is quite developed now (see e.g. Kraft and Kraft, 1978; Akarca and Long, 1980; Erol and Yu, 1987; Masih and Masih, 1996, 1998; Soytas and Sari, 2003; Oh and Lee, 2004; Chen *et al.*, 2007; Yuan *et al.*, 2008; Apergis and Payne, 2009; Chandran *et al.*, 2010; Lang *et al.*, 2010); although there has not been an empirical consensus on the direction of the causality or, for that matter, the existence of causality relationship between electricity consumption and economic growth.

Most of the above-mentioned studies have employed bi-variate models encompassing growth and electricity consumption. This may not be the right

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approach in understanding the growth and energy relationships because of the omitted variables bias (Tang, 2009). This paper employs a tri-variate approach in order to understand the potential relationship between electricity consumption, foreign direct investment (FDI) and economic growth through the use of co-integration and vector error correction mechanism.

The inflow of FDI in an economy develops the major sectors of the country, thereby prompting enhanced production, manufacturing and transportation activities. Naturally, this inflow of FDI induces greater electric power consumption, justifying the rationale of studying electric power consumption and FDI relationship. Literature on electricity consumption – FDI – economic growth nexus is scarce. A few studies like Tang (2009) for Malaysia, Bekhet and Othman (2011) for Malaysia and Bento (2011) for Portugal, have studied the potential relationships between the three variables. The present study adds to this strand of literature. Also for the first time, in this scenario, this paper uses two economies (India and Pakistan), provides a comparative analysis of the empirical results and presents prospective explanations for the observed causality differences between the two economies.

The rest of the paper is organized as follows. Section 2 presents the review of the literature. Section 3 provides a summary of the energy profiles of the two countries, India and Pakistan. Section 4 encompasses the research methodology and the data along with its sources. Section 5 includes the empirical findings and Section 6 concludes the paper.

2. Literature review

Literature contains numerous instances where researchers have tried to explore the relationship between electric power (electricity) consumption and economic growth. There are researchers who have claimed that it is the electric power consumption which causes economic growth (Narayan and Singh, 2007; Narayan and Prasad, 2008; Apergis and Payne, 2009; Chandran *et al.*, 2010), whereas others insist on the causality running from economic growth to electric power consumption (Yoo and Kim, 2006; Lean and Smyth, 2010). A few of them maintain a bi-directional causality existence between the two variables (Yoo, 2005; Akinlo, 2008; Odhiambo, 2009; Lang *et al.*, 2010), whereas instances of no causality have also been recorded (Akarca and Long, 1980; Yu and Hwang, 1984; Erol and Yu, 1987; Soytas and Sari, 2003; Chen *et al.*, 2007). Yoo and Lee (2010), in their panel data study of 88 countries for 1975-2004 time period, emphasized the need of energy efficiency improvement in case of developing countries.

Chen *et al.* (2007) estimated relationships between electric power consumption and economic growth for a sample of ten newly industrializing and developing Asian countries (China, Hong Kong, India, Indonesia, Korea, Malaysia, Philippines, Singapore, Taiwan and Thailand). For a time period comprising 1971-2001, they found unidirectional causality from economic growth to electricity consumption in the short-run and bi-directional causality between the variables in the long run when they considered the complete panel of ten countries. Through their empirical evidence for the study, they insisted on the application of electricity conservation policies and avoiding redundant expenditure of electricity.

In a pioneer study on the impact of FDI on energy consumption and economic growth relationship, Tang (2009) used co-integration and causality analysis over a period of 1970-2005 to study the electricity consumption function for Malaysia. The results of the study showed positive impact of FDI on electricity consumption in Malaysia. Bekhet and Othman (2011) studied the relationship between electricity

consumption, consumer price index (CPI), total consumption expenditure, economic growth (proxied by GDP) and FDI for Malaysia. Using vector error correction mechanism for a period of 1971-2009, long-run causality was estimated from electric power consumption to GDP growth. This signifies the contribution of electricity consumption in order to achieve long-term and sustainable growth. Bento (2011) used annual data from 1980-2007 for Portugal in order to unleash potential relationship between primary energy consumption, economic growth and net inflows of FDI. The empirical analysis provided support for long-run linear co-integration between the three variables. Positive relationship between energy consumption and growth was found, whereas, negative impact of FDI on economic growth was established through the empirics of the study.

Masih and Masih (1998) used a tri-variate vector error correction model (VECM) to find a unidirectional causality running from energy consumption to growth. Soytas and Sari (2003) also estimated energy to growth causality for Turkish sample. In a study on Pakistani sample, Aqeel and Butt (2001) used co-integration and Hsiao's Granger causality technique to raise evidence of causality running from electricity consumption to economic growth.

For a sample of Asian countries, Yoo (2006) found evidence of bi-directional granger causality between electric power consumption and economic growth over a period of 1971-2002. Oh and Lee (2004) also presented similar bi-directional causality for South Korean sample. Yuan *et al.* (2008) used a neo-classical aggregate production model to check the relationship between economic growth and energy consumption in a Chinese setting. They found a long-run co-integration among output, capital, labor and energy use. Granger causality tests indicated causality running from electricity and oil consumption to GDP and also from GDP to total energy, coal and oil consumption. Yang (2000) and Paul and Bhattacharya (2004) have established a bi-directional causality between GDP and energy consumption for Taiwan and India, respectively. Jumbe (2004) found bi-directional impact evidence between electricity consumption and economic growth in the case of Malawi considering the time span of 1970-1999.

Kraft and Kraft (1978), in one of the pioneer studies on energy – growth nexus, found causality evidence from GNP to energy consumption for US economy over the time period of 1947-1974. Masih and Masih (1996) also established causality running from growth to energy for Indonesian sample. Dhungel (2008), using co-integration and VECM, estimated causality relationships between per capita consumption of coal, electricity, oil, total energy and per capita GDP. The empirical evidence gathered for the Nepalese sample over a period of 1980-2004 indicates unidirectional causality running from per real GDP to electric power consumption. Shahbaz and Feridun (2012) used autoregressive distributed lag (ARDL) bounds testing methodology in order to study the relationship between electric power consumption and economic growth. The study based on data from Pakistan over the 1971-2008 time period indicated a long-run integration between electricity consumption and economic growth, with growth leading to electricity consumption.

Ghosh (2002) studied Indian data for electricity consumption and economic growth relationship over a period of 1950-1997. He found no co-integration between the two variables. However, he maintained that a unidirectional causality existed between them, where the causality was argued to run from economic growth to electricity consumption; although the results of the estimation contradicted with the postulation of Granger (1986).

Cheng and Lai (1997) found a unidirectional causality between energy consumption and economic growth, where causality ran from economic growth to energy consumption for Taiwan (Republic of China); whereas, a bi-directional causality between energy consumption growth and GNP growth was observed for the Taiwan (Republic of China) sample by Hwang *et al.* (1991).

3. Energy profiles of India and Pakistan[1]

India contains 15 percent of the world's population, was fourth largest oil consumer in 2008 after the USA, China, Japan and a significant consumer of energy resources. India does not possess enough energy resources, domestically. For this reason, India has to import a considerable portion of its requirements. Electrification rates were about 65 percent in 2008 with nearly 400 million people not having access to electricity. Almost all of India's electric power is generated from coal, oil or gas. India also faces severe electricity generation shortage. Energy policy and planning of India is controlled and devised by the Ministries of Power and Coal. In all, 65 percent of India's electric power is generated by thermal power plants, 10 percent by renewable energy sources, 22 percent by hydroelectric plants and about 3 percent by nuclear power plants. Recently, India has made significant contributions to its nuclear and wind-generated electricity resources. Also there are plans to induce solar energy capacity into the system in the next decade or so.

Electricity generation in Pakistan is heavily reliant on fossil fuels and hydroelectric sources. Pakistan has been hit by major electric power crisis in the past few years having vast differences between demand and supply estimates. Long load-shedding schedules have badly hurt the businesses and their development capabilities. Pakistan is abundant in energy resources but due to instability and inefficient planning, there have not been major contributions by private sector in unfolding these potential resources. In all, 64 percent of Pakistan's electric power is generated by fossil fuels, 34 percent by hydroelectric sources and about 2 percent by nuclear resources.

Due to recent up-shifts in the foreign investments and technological upgrading for both the economies, electric power consumption has increased significantly in the recent years, moving from 276 and 267 kWh per capita in 1990 to 402 and 357 kWh in 2000 to 566 and 432 kWh in 2008 for India and Pakistan, respectively. Electric power consumption of India and Pakistan as compared to the world and South Asia is shown in Figure 1.

Figure 1 clearly shows an upward trend in the electric power consumption of India and Pakistan.

4. Methodology and data

In order to study the causality relationship between electric power consumption, FDI and economic growth, Engle-Granger methodology (Granger and Newbold, 1974; Engle and Granger, 1981) was employed. To test for stationarity, Augmented Dickey-Fuller (ADF) (Dickey and Fuller, 1981) and Phillips-Perron (PP) (Phillips and Perron, 1988) tests were used.

The error correction model was estimated as:

$$\begin{aligned}\Delta EG_t = {} & A_{21}(L)\Delta EG_{t-1} + A_{22}(L)\Delta FDI_{t-1} \\ & + A_{23}(L)\Delta EPC_{t-1} + \delta_{EG} ECT_{t-1} + \varepsilon_{2t}\end{aligned} \tag{1}$$

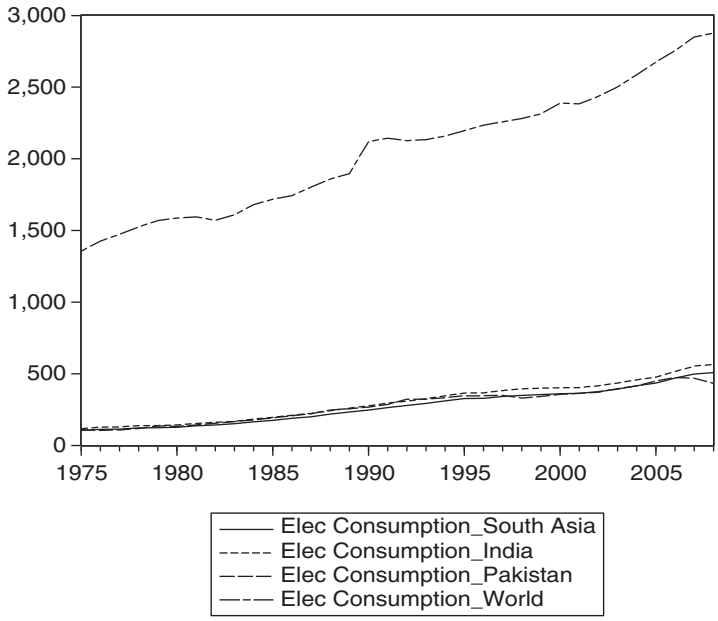

Figure 1.
Energy profiles of India and Pakistan compared with world and south Asian profiles

$$\Delta FDI_t = A_{11}(L)\Delta EG_{t-1} + A_{12}(L)\Delta FDI_{t-1} + A_{13}(L)\Delta EPC_{t-1} + \delta_{FDI} ECT_{t-1} + \varepsilon_{1t} \quad (2)$$

$$\Delta EPC_t = A_{31}(L)\Delta EG_{t-1} + A_{32}(L)\Delta EDI_{t-1} + A_{32}(L)\Delta EPC_{t-1} + \delta_{EPC} ECT_{t-1} + \varepsilon_{3t} \quad (3)$$

where EG_t, FDI_t and EPC_t represent economic growth, FDI and electric power consumption, respectively.

Δ represents the difference operator.

A_{ij} represents the polynomials in the lag operator L.

ECT represents the lagged ECT obtained from long-run co-integrating relationship.

ε_t represents the ECT, assuming to be uncorrelated and random with a zero mean.

δ represents the dependent variable's deviation from long-run equilibrium.

Now, if the three variables *EG*, *FDI* and *EPC* are co-integrated, then atleast one or all of the ECTs should be significantly non-zero. Granger causality is tested using the simple t-test of δ, joint Wald F-test of significance of each explanatory variable's sum of lags and then by a joint Wald F-test of the following terms:

$$(\delta_{EG} \text{ and } A_{22}),\ (\delta_{EG} \text{ and } A_{23}) \quad (4)$$

$$(\delta_{FDI} \text{ and } A_{11}),\ (\delta_{FDI} \text{ and } A_{13}) \quad (5)$$

$$(\delta_{EPC} \text{ and } A_{31}),\ (\delta_{EPC} \text{ and } A_{32}) \quad (6)$$

I have used annual time-series data ranging from 1975-2008 for India and Pakistan. The data were obtained from World Bank's World Development Indicator's (WDI) online database. The time period selection was based on data availability constraint. The variables used in this study include economic growth represented by log of real GDP per capita (constant US$2000), FDI – net inflows (percentage of GDP) and log of electric power consumption (kWh per capita). Table I presents the descriptive statistics for the variables used in the study.

5. Empirical results

5.1. Unit root tests (ADF and PP)

Table II reports the findings for the ADF and the PP tests. It is evident from the table that all the three variables are non-stationary at level using ADF test for both the countries. The variables are first differenced and the ADF and PP tests are again applied. Both the ADF and PP tests indicate that all the variables are stationary at $I(1)$ for India and Pakistan, which means that the three variables are integrated of order one.

Variable	Observations	Mean	SD	Minimum	Maximum
Economic growth (EG)					
India	34	5.844	0.357	5.389	6.568
Pakistan	34	6.094	0.223	5.688	6.467
Foreign direct investment (FDI)					
India	34	0.517	0.777	−0.030	3.576
Pakistan	34	0.865	0.945	0.062	3.904
Electric power consumption (EPC)					
India	34	5.602	0.489	4.757	6.339
Pakistan	34	5.525	0.477	4.656	6.158

Table I.
Descriptive statistics

Country/variable	Augmented Dickey-Fuller (ADF) test		Phillip-Perron (PP) test	
	$I(0)$	$I(1)$	$I(0)$	$I(1)$
India				
EG_t	−1.003	−5.033***	−0.779	−5.044***
FDI_t	2.954	−3.205**	4.469	−4.447***
EPC_t	−2.947	−4.403***	−1.254	−4.702***
Pakistan				
EG_t	−1.867	−4.376***	−1.672	−4.357***
FDI_t	−1.313	−3.822***	0.007	−3.587**
EPC_t	−0.762	−3.946***	−0.360	−3.952***
Critical values (w/o trend)				
1%	−3.654	−3.654	−3.646	−3.654
5%	−2.957	−2.957	−2.954	−2.957
10%	−2.617	−2.617	−2.616	−2.617
Critical values (with trend)				
1%	−4.273		−4.263	
5%	−3.558		−3.553	
10%	−3.212		−3.210	

Table II.
Unit root test results

Notes: [a]Number of lags selected using the Akaike Information Criteria (AIC). ***Means that the null of the unit root in the ADF and PP tests is rejected at 1 percent and 5 percent significance level

5.2. Co-integration test (Johansen's tests for co-integration)

Table III reports the results of Johansen's procedure (Johansen, 1988; Johansen and Juselius, 1990). This procedure was adopted because all the variables were co-integrated of the same order. Appropriate lag length was selected using Akaike's Information Criterion (AIC).

It can be seen from the results of Table III that the null hypothesis of no co-integration relationship can be rejected at 5 percent level against the alternative hypothesis of the presence of co-integrating relation for India and Pakistan. This indicates the presence of Granger causality among the variables; however, the direction of the causality cannot be specified yet.

5.3. Error control mechanism

Through error correction mechanism, the direction of causality was established between the variables. ECTs were incorporated in the analysis because an analysis without including ECTs is intended to give unreliable results (Adjaye, 2000). Also, we can distinguish between short- and long-run Granger causality by using this mechanism. Table IV indicates the results of the temporal Granger causality tests.

Referring to Table IV, none of the variables (economic growth, FDI and electric power consumption) caused each other in the short run.

Country	Null hypothesis	Eigenvalue	Test statistics[a]	5% critical value
India				
	$r=0\ r=1$	0.662	33.606*	21.132
	$r=1\ r=2$	0.399	15.778*	14.265
	$r=2\ r=3$	0.0005	0.015	3.841
Pakistan				
	$r=0\ r=1$	0.591	27.743*	21.132
	$r=1\ r=2$	0.263	9.471	14.265
	$r=2\ r=3$	0.0097	0.304	3.841

Notes: [a]Test statistics are maximum eigen-statistics. Lag length was chosen using AIC. *Significant at 5 percent level

Table III.
Results of Johansen co-integration test

	Short-run effects			Vector error correction model (VECM) estimation			
	ΔEG	ΔFDI	ΔEPC	ECT[a]	ΔEG	ΔFDI	ΔEPC
Country/dependent variable	Wald's *F*-statistics						
India							
ΔEG	–	0.113	0.009	5.564**	–	3.422**	3.047*
ΔFDI	0.481	–	0.220	6.164**	6.620***	–	3.184*
ΔEPC	1.740	0.120	–	1.765	1.104	0.883	–
Pakistan							
ΔEG	–	0.701	1.799	0.564	–	0.427	1.407
ΔFDI	0.899	–	0.381	0.506	0.780	–	0.351
ΔEPC	2.706	0.784	–	2.915*	3.264*	2.927*	–

Notes: [a]ECT refers to the error correction term. *,**,***Significant at 10, 5 and 1 percent, respectively

Table IV.
Temporal Granger causality results

Electric power consumption and FDI cause economic growth for India in the long run. The empirical evidence suggests that 1 percent change in electric power consumption and FDI individually causes a 3 percent change in economic growth. Also, electric power consumption and economic growth cause FDI in the long run in the case of India; where 1 percent change in electric power consumption and 1 percent change in economic growth cause a 3 and 7 percent change in FDI, respectively. Also the significance of the ECT indicates that the three variables interact to re-establish the long-run equilibrium in the case economic growth and FDI diverge from the equilibrium position. Our results of causality not running from economic growth to electric power consumption, in the case of India, negate the argument by Ghosh (2002) who were motivated of this causality relationship.

For Pakistan, the causality evidence was totally opposite to that of India. Economic growth and FDI were found to cause electric power consumption in the long run. Based on the empirics, 1 percent change in FDI and 1 percent change in economic growth cause 3 percent change in electric power consumption. Our results for Pakistan are consistent to those of Shahbaz and Feridun (2012), who have provided evidence of long-run co-integration between economic growth and electricity consumption and that economic growth impacts electricity consumption in the long run. No evidence for electric power consumption causing economic growth was established in our results, thereby, negating the existence of such relationship in the study of Aqeel and Butt (2001) for Pakistani sample.

6. Conclusion and policy implication

The purpose of this study was to find causality and comparative relationships between electric power consumption, FDI and economic growth for India and Pakistan. Granger causality tests and error correction mechanism were implemented in order to check short- and long-run causalities between the three variables. Our analysis does not approve the existence of any short-run causality relationships between the three variables for both the countries. In the long run, electric power consumption granger causes both economic growth and FDI (EPC $\rightarrow$ EG and EPC $\rightarrow$ FDI) for India; whereas bi-directional relationship was estimated for FDI and economic growth (FDI $\leftrightarrow$ EG). The bi-lateral relation between FDI and economic growth is consistent with the findings of Choe (2003).

India is a service-oriented economy. It is mostly reliant on internal (or domestic) factors rather than external. This was the reason that the recent global crisis did not impact the Indian economy longer (it recovered faster than many other economies), although the shocks were felt. Nevertheless, the role of foreign capital in an economy's growth is undeniable; and our empirics also proved the same relationship between FDI and economic growth for India. India, on one hand, is a prospective venue for investment; but on the other front, it faces severe electricity dearth. Electric power consumption positively impacts economic growth and FDI for India which means that policies need to be designed in order to attain more electricity consumption. This is only possible when alternative resources are adopted. India has been aware of the issue and is seriously planning in this regard.

In the case of Pakistan, FDI and economic growth were observed to cause electric power consumption in the long run (FDI $\rightarrow$ EPC and EG $\rightarrow$ EPC).

Pakistan has a semi-industrialized economy. Technological innovations and enhancements have registered a sharp boost up to the electric power consumption in Pakistan, as more and more industries are adopting modern tools and techniques.

Therefore, increased inflows of FDI have brought up a rise in the electric power consumption for Pakistan. It is a well-established fact that FDI, through technology and skills transfer (Findlay, 1978), augments economic growth (Borensztein *et al.*, 1998; De Mello, 1999; Hayami and Godo, 2005). For this reason, it may be concluded that FDI, directly and through its interaction with economic growth, enhances the electric power consumption in Pakistani economy.

Our findings have a number of policy implications for the two countries in specific and other developing countries in general. India should plan for alternate sources of electricity in the long run, as enhanced electric power consumption is positively related to economic growth and FDI. For Pakistan, growth is not dependent on electric power consumption. Therefore, any strategies to increase or decrease the consumption of electricity will not add to the growth capability of Pakistan. However, Pakistan should also aim for alternate, stable, cost-effective and environment friendly sources of electricity rather than relying heavily on fossil fuels. Both the countries should devise policies which relate to energy conservation procedures and finding new energy resources in order to consume them in the long run. Alternate energy sources should be the focus of future strategies in relation to long-term energy management.

Note

1. Retrieved from "The US Energy Information Administration (EIA)" and country-specific sources.

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