ELECTRICITY CONSUMPTION AND ECONOMIC GROWTH: A VAR MODEL FOR THE NEW ECONOMY OF PAKISTAN

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Abstract

The economy of Pakistan had always been plunged due to its severe electricity shortages over the last two decades and persistently faces challenges in revamping its electricity supply network. The China Pakistan Economic Corridor (CPEC) is considered as a productive shock which has opened up new avenues for the energy sector in Pakistan. This study is an endeavor to incorporate the impact of such shock in the production function and to revisit the dynamics between electricity consumption and economic growth (ECEG) in the new economy of Pakistan for the time span of 1971-2018. The study has employed Vector Autoregression (VAR) model, including capital formation, labor participation, openness of the economy and financial development. The findings of the study affirmed the neutrality hypothesis while cointegration estimates jagged long run effectiveness for ECEG nexus. Keeping in view the internal and external bottlenecks, it is thus recommended to revise the ECEG model for the new economy of Pakistan keeping in view the revival of industrial sector removing the inefficiencies of the power sector.

Keywords: Electricity Consumption, Economic Growth, CPEC, VAR Model.

Introduction

Background of the Study

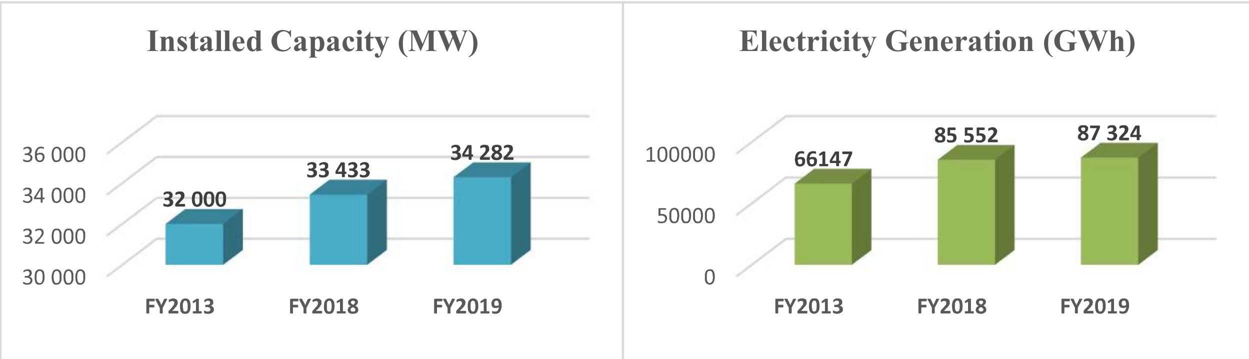
It is a well-established fact that economists of contemporary era are more concerned to explore the dynamics of energy economics due to its increasing demand and supply gaps. These gaps are alarming not only for economic activities but also in the globalization process. Hence, the conventional theory has not enough to say about the association between energy and economic growth. This could be the reason that a comprehensive model of growth incorporating energy as main determinant is missing in economic theory. Turning to the plausible explanation of this gap in theory, it could be attributed to various reasons. First, economists argued that energy is an essential input for growth and development while its consumption is supposed to play a preventive role as other inputs may perform well without energy (Razzaqi, Bilquees, & Sherbaz, 2011). Second, the growth of the energy sector relies on the economic structure of the economy under consideration which may or may not be taken into account in recent years. Despite, energy economists decline these arguments based on the differences at the micro and macro level as economic processes require different methods (direct and indirect) of production. Intuitively, this conflict opens up a wide range of macroeconomic parameters to be included in the energy-growth model.

The economy of Pakistan had been plunged due to its severe electricity shortages over the last two decades and thus persistently faces a significant challenge in revamping its network responsible for the supply of electricity (Nawaz, Iqbal, & Anwar, 2013). This in turn had created a huge gap in demand and supply of electricity showing inability of the electricity sector to meet the demand for the growth of the emerging economy of Pakistan. The China, Pakistan Economic Corridor (CPEC) is considered as a productive shock which has opened up new avenues for the energy sector as it endowed a major segment of its investment in the generation of electricity in Pakistan. According to Pakistan Economic Survey (PES) 2018-19, Pakistan has successfully detached bottlenecks of the electricity generation after the completion of the early harvest stage, during last tenure. This demands a comprehensive assessment of the electricity sector, specifically in lieu of the inauguration of CPEC.

Overview of Electricity Sector in Pakistan

This section provides a brief overview of the electricity sector in Pakistan through the lenses of installed capacity and electricity generation. Figure 1 presents the comparison between the two in Pakistan from Fiscal year (FY) 2013 to 2019. The figure provides a glimpse that installed capacity of Pakistan has been persistently increasing since 2013 while showing a growth of 2.5 percent in the given time period.

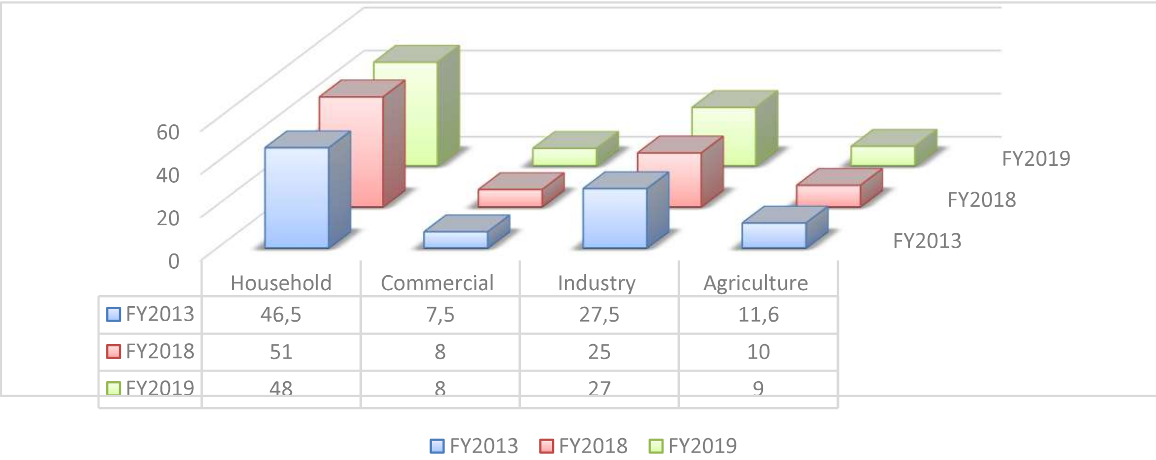
Figure 1: Comparison between Installed Capacity and Electricity Generation



Source: Ministry of Energy, Hydrocarbon Development Institute of Pakistan (HDIP)

Furthermore, the electricity generation varies from year to year and showed a surge in generation from 66 Gegawatt hours (GWh) to 87 Gwh in last few years (2013-19), however, this trend has not been assertively transmuted in electricity consumption. This could be due to the reliance of electricity sector on input inaccessibility, financial constraints and low performance of Generation Companies (GENCOs) of the public sector (PES, 2018-19).

Figure 2: Percentage Distribution of Electricity Consumption



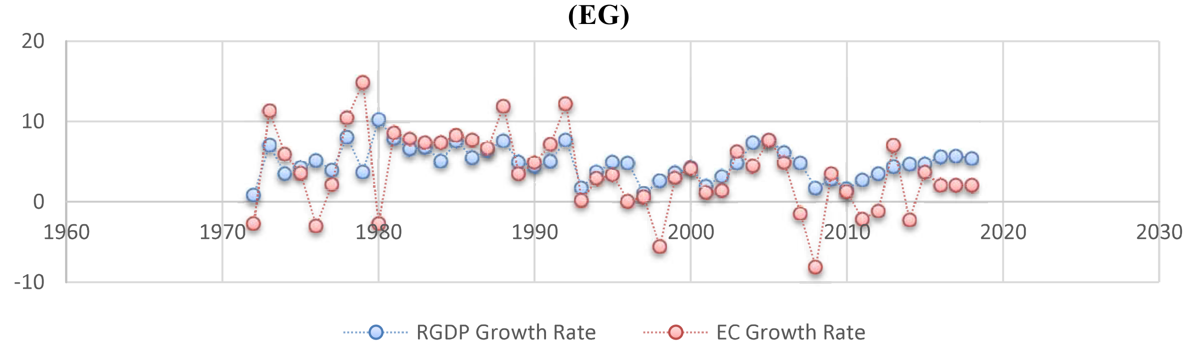
Source: Hydrocarbon Development Institute of Pakistan (HDIP); Pakistan Economic Survey, 2018-19

Turning to the consumption of the generated electricity, the segmentation reveals a significant deviation in the electricity consumption by its buyers from 2013-2019. In the preceding year, there was a decreasing trend in electricity consumption of household and agriculture sector due to consumer rationalization and enhancement in electricity tariffs. A slightly positive trend had also been observed in the industrial sector pointing a revival of deteriorating industrial sector, despite, household segment is yet a major consumer (PES, 2018-19).

Trends in Electricity Consumption (EC) and Economic Growth (EG)

The electricity consumption and economic growth (ECEG) nexus has been widely discussed in the literature due to its supposed prominence in determining the growth patterns of the economy. Figure 3 elucidates trends in electricity consumption (EC) and economic growth (EG) of Pakistan.

Figure 3: Trends in Electricity Consumption (EC) and Economic Growth (EG)



Considering the growth rates, it is well evident that there is an inconsistent link between electricity consumption and real gross domestic product (GDP) from 1970s to 1980s due to inefficient and ineffective policy measures (Zeeshan & Ahmed, 2013). Besides, after 1980s and at the end of 1990s, the trend was steady while in later years a variation had been notified. It can be concluded that ECEG data are found to be symmetric for initial years while it showed a little irregularity in the late few years. The probable clarification for this pattern is the process of rapid urbanization, industrialization and electrification in rural areas had experienced an inducement effect on overall demand of electricity (Nawaz et al. 2013). The incompatibility of energy policy making with the growth policies of the economy was also a prominent factor.

Contemporarily, the electricity sector of Pakistan is going through structural and institutional changes, this study is an endeavor to revisit the ECEG model in the context of new economy of Pakistan with few innovations. First, the ECEG model has been revisited bringing the insight of the high - volume shock of CPEC in the power sector. For this reason, we have applied the Vector Autoregression (VAR) model with a divergent set of control variables. The stability of the variables to such shocks has been tested and evaluated through the Impulse Response Function (IRF) and Variance Decomposition (VDC) methods. The findings of the study are integrated with the internal and external bottlenecks with discussion on the power sector reforms of the new economy of Pakistan.

Literature Review

The energy-based literature was pioneered with the study by Berndt and Wood (1975) as the authors observed the energy consumption and associated its substitution with labor and complementarity with capital in the industrial processing. In an extended study with the same data, Griffin and Gregory (1976) contradicted the complementarity of capital with energy consumption. Turning to the development of econometric methods, the study of Kraft and Kraft (1978) had been extensively quoted as inventive in the ECEG literature. Since then, continuing efforts were made to investigate the ECEG model featuring different countries subjected to the objectives of the respective studies. Table 1 provides a compilation of different studies in panels to figure out the gist of the existing literature. This has assessed to segregate the studies in different panels and meanwhile to figure out the gap in the national literature.

Table 1: Compilation of Studies on EGEC Nexus

S.No.	Author (s) & Year of Publication	Country (s)	Data	Methodology	Findings
Panel I: Aggregate Compilation					
1	Yasar (2017)	Panel of 119 economies	1970-2015	Panel ARDL & Granger Causality	EC →EG
2	Omay (2014)	G7 economies	977-2007	Exponential Smooth Transition (ESTAR) model & Panel VECM	EC →EG

3	Dogan (2014)	Sab-Sahara African economies	1971-2011	Johansen Cointegration	EC →EG
4	Razzaqi et al. (2011)	D8 (Bangladesh, Egypt, Indonesia, Iran, Malaysia, Nigeria, Pakistan & Turkey)	1980-2007	VEC Modeling & VAR Granger Causality	EC →EG (Iran & Nigeria) EG →EC (Bangladesh, Egypt, Malaysia, Pakistan & Turkey) Neutral (Indonesia)
5	Apergis & Payne (2010)	OECD economies	1985-2005	Panel Cointegration & ECM	Bidirectional Causality between EC & EG
6	Lee & Chang (2008)	16 Asian economies	1971-2002	Panel Cointegration & Causality	EC →EG (long-run only)
7	Akinlo (2008)	11 Sab-Sahara African economies	1980-2003	Panel ARDL, Granger Causality & VECM	Bi-directional (Gambia, Ghana and Senegal) EG →EC (Sudan and Zimbabwe) Neutral (Cameroon and Cote D'Ivoire) No causality (Nigeria, Kenya & Togo)
8	Mehrara (2007)	11 selected oil exporting economies	1971-2002	Panel Cointegration	EG →EC
9	Asafu-Adjaye (2000)	India, Indonesia, Philippines & Thailand	Unbalanced Panel data 1973-1995 (India & Indonesia), 1971-95 (Thailand and Philippines)	Cointegration & ECM	EC →EG (India & Indonesia) Bi-directional (Thailand & Philippines)
10	Soytas & Sari (2003)	G-7 economies	Unbalanced Panel data	Granger Causality & ECM	Neutrality
Panel II: Disaggregate Compilation (International Studies)					
11	Khan et al. (2018)	Kazakhstan	1991-2014	ARDL Bound Testing & VECM Granger Causality	EC →EG
12	Shahbaz et al. (2017)	India	1960Q1–2015Q4	Non-Linear Autoregressive Distributed Lag (NARDL)	EC →EG (Asymmetric causality due to negative shocks only)
13	Solarin et al. (2016)	Angola	1971-2012	ARDL, Granger Causality & VECM	EC →EG
14	Pempetzoglou (2014)	Turkey	1945-2006	Linear Granger Causality Test & Nonparametric	EG →EC

				Diks-Panchenko Causality Test	
15	Kasperowicz (2014)	Poland	2000-2012	Granger Causality Test	EC →EG EG →EC
16	To et al. 2012	Australia	1970-2011	Bound Testing Cointegration & Multivariate Granger Causality	EC →EG (Direct yet weak link between EC & EG)
17	Shahbaz et al. (2011)	Portugal	1971-2009	ARDL, Unrestricted Error Correction Model (UECM), VECM	Bi-directional causality between EC & EG
18	Odhiambo (2010)	Kenya	1972-2006	Cointegration & ECM	EC →EG
	Zang & Cheng (2009)	China	1960-2007	Causality, Generalized Impulse Response	EG →EC
19	Odhiambo (2009)	Tanzania	1971-2006	ARDL Bounds Testing & Causality	EC →EG (Long –run causality between EC &EG)
20	Altinay & Karagol (2005)	Turkey	1950-2000	Granger Causality & VAR	EC →EG
21	Paul & Bhattacharya (2004)	India	1950-1996	Engle-Granger Cointegration & Granger	EG →EC (Engle-Granger) EC →EG (Granger)
Panel III: Disaggregate Compilation (National Studies)					
22	Nadeem & Munir (2016)	Pakistan	1972- 2014	ARDL Bound Testing & Granger Causality	Long run causality between EG and EG
23	**Zeshan & Ahmed (2013)**	Pakistan	1971-2012	Structural Vector Auto-regression (SVAR)	Instable model of EC and EG
24	**Nawaz et al. (2013)**	Pakistan	1971-2012	Smooth Transition Autoregressive (STAR)	Long-run association between EG and EC
25	**Shahbaz & Lean (2012)**	Pakistan	1972-2009	ARDL Bounds Testing, Granger Causality, VECM Granger Causality	Bi-directional causality between EC & EG
26	**Shahbaz & Feridun (2012)**	Pakistan	1971-2008	ARDL & To-daYamamoto	EG →EC (Long span causality)

				and Wald-test causality	
27	**Atif & Siddiqui (2010)**	Pakistan	1971-2007	Engle & Granger Cointegration Tests	EC →EG
28	**Aqeel & Butt (2001)**	Pakistan	1956-1996	Cointegration &Hsiao's version of Granger Causality	EG →EC

Panel I show that aggregate studies revolved around exploring the causal associations between the core variables of EC and EG. These studies were supposed to provide sophisticated findings and thus the scholars preferred panel Auto Regressive Distributed Lag (ARDL), Vector Error Correction Model (VECM) and cointegration analyses. The studies of Yasar (2017), Omay (2014), Dogan (2014), Lee and Chang (2008); and Asafu-Adjaye (2000) ended up on on-way causality running from EC to EG. Akinlo (2008) and; Apergis and Payne (2010) found a two-causality using same econometric methods while Mehrara (2007) explored an evidence of conservative hypothesis for ECEG model given the selected samples of economies. Additionally, Razzaqi et al. (2011) quoted country-specific causalities in the panel of D8 economies and; Soytas and Sari (2003) found the neutrality evidence. It is pertinent to mention here that there is a limited literature on ECEG nexus for South Asian economies pointing a research gap in the literature. Turning to the time trend analyses in panel II, it consists of huge literate that discusses all three main hypotheses focusing the ECEG nexus. The hypothesis of growth were recently affirmed by Khan et al. (2018), Solarin et al. (2016), To et al. (2012); and Odhiambo (2010, 2009) for the economies of Kazakhstan, Angola, Australia, Kenya and Tanzania respectively. Further, Zang and Cheng (2009) explored conservative causality for China while Shahbaz et al. (2011) disclosed two-way causality for Portugal. On a concluding note for trend studies, scholars continued to explore the nexus through different model specifications, providing diverging findings even for same economies. For instance, Shahbaz et al. (2017) indicated a one-way causality from electricity consumption to economic growth in the economy of India employing the non-linear estimation technique. The author also pointed an asymmetry in the model due to negative shocks in the economy, denying the possibility of reverse causality. Contrary to this, Paul & Bhattacharya (2004) already declared two-way causality favoring the feedback hypothesis of ECEG in India using two different Granger techniques of causality. Additionally, Pempetzoglou (2014) and Altinay and Karagol (2005) quoted causalities in a different direction for the economy of Turkey.

Starting from the national study of Nadeem and Munir (2016) in panel III, the ARDL estimation provided a recent declaration favoring the ECEG association (long run) for the time span of 1972-2014. Shahbaz and Lean (2012) also developed the same dynamic model of ARDL and elucidated a bi-directional ECEG causality. In the same year, Shahbaz and Feridun (2012) developed the ECEG model for a different time span and concluded a reverse causality between the two core variables. Atif & Siddiqui (2010) found a one-way causality while Aqeel and Butt (2001) ended up on reverse causality from EC to EG. Contrary to the literature on ECEG perspective, there is recently a turn in national studies from traditional causality analyses to more impressive yet sophisticated econometric applications and findings. In this regard, Zeshan and Ahmed (2013) applied the SVAR for the time period of 1971-2012 and found an instable ECEG model. The authors stressed-on enhancement of energy inputs to facilitate capital stock in consonance with more labor utilization. Correspondingly, Nawaz et al. (2013) explored the traditional long run perspective with the STAR model and further explored insensitivity of electricity consumption to prices and associated it with lack of electricity alternatives.

In the nutshell, there exist extensive studies capturing the causal associations and dynamics of ECEG nexus at both aggregate and disaggregate level. Further, there are variations in the findings due to multifarious data spans, econometric applications and analyses. Besides, national studies are now more inclined towards assimilating the issues of electricity sector with the advanced econometric techniques.

Methodology

Data

We have extracted six variables from the extensive literature on the ECEG linkage in order to maintain the compliance of the study. The data has been collected from both national and international data sources for the time span of 1971-2018. The variables of the VAR model include electricity consumption (EC), economic growth (EG), capital formation (KF), labor participation (LP), openness of economy (OE) and financial development (FD). The details of the variable in the model with proxies, units of measurement and sources of the data have been presented through table A1 in appendix A.

Unit Root Tests

The VAR model requires a stationarity test of all the variables included in the estimation. Thus, non-stationary series must be aptly transmuted prior to the model estimation to avoid spurious regressions and distortions in the model (Stock and Watson, 1989; Nelson & Plosser, 1982). Therefore, the traditional econometric procedure of Augmented Dickey Fuller (ADF) has been followed opting the Akaike Information Criterion (AIC) considering the intercept and trends.

Vector Autoregression (VAR) Model

The study has employed a VAR model to examine the contemporaneous outcomes of variables on each other (Ulrichs, 2018). This model is frequently used to predict multivariate system of time series and to analyze the dynamic yet random nature of the disturbance terms of the system. The VAR treats all variables in the model as endogenous and meanwhile it does not restrict to execute prior margins on structural connotations among variables (Soytas, Sari, & Ozdamir, 2001). As a result, doing so would allow to presume that deviations in particular indicator are linked to its lagged values and meanwhile to changes in other variables and their respective lagged values. Besides, VAR expresses exploratory variables in the form of lagged values (pre-determined); so here we represent the following reduced expression of the model;

$$y_t = c + \sum_{i=1}^{n} \varphi_i \, y_{t-1} + \varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. (\mathbf{1})$$

Where;

$y_t = Vector\ of\ all\ variables\ (n\text{x}1)$

c = Intercept vector of VAR $(c_1, \ldots.., c_5)$

$\varphi_i = ith\ matrix\ Autoregressive\ coefficients \qquad For\ I = 1,2,3, \ldots..., p$

and;

$\varepsilon_t = \ generalization\ of\ white\ noise\ process\ (\boldsymbol{\varepsilon_t}, \ldots\ldots., \boldsymbol{\varepsilon_{nt}})$

Equation 1 can also be transformed into the following Moving Average (MA) form (equation 2) in order to perform analysis of responses of variables in the system to shocks;

$$y_t = \ \mu + \sum_{i=0}^{\infty} \gamma_i \varepsilon_{t-i} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. (\mathbf{2})$$

Where, $\gamma_i$denotes identity matrix and μ shows the mean of the process.

On the whole, the illustration of VAR enables to explain a one-unit change in innovations on the variables of the system under consideration. Additionally, the MA form of VAR assesses to generate the forecasts (error variance) through IRF and VDC as both are employed to observe the nominal as well as the real significance of shocks.

VAR Stability Test

The stability test is a pre-requisite assesses to decide that whether the VAR model under consideration would be feasible or not. This implies that all the roots of the circle must lie within the range of the circle and modulus roots must be necessarily less than 1(Asmah, 2013).

VAR Lag Selection Criteria

The VAR selection criteria essentially describe the dynamic features of the model more precisely given the possibility of long lag lengths (Kilian & Lutkepohl, 2017). Whereas, scholars usually prefer to avoid long lags due to decrease in degrees of freedom. Practically, the lag length of VAR is calculated through various selection criterion with a rule of thumb of adopting the specific lag selected by maximum information criterion.

VAR Granger Causality/Block Exogeneity Tests

The data analysis proceeds with employing VAR Granger Causality tests to elucidate the causality in short span determining dynamic perspective appropriately (Sargent, 1977). The test has been applied to check the running between economic growth and electricity consumption and among other variables, given the fact that these may have or may not have effective consequences.

Impulse Response Function (IRF)

After the estimation of VAR, the efficacy of the model will be tested through applying the Impulse Response Function (IRF). The IRF signifies the mechanism through which any certain shock (positive or negative) exhibits spread over time. It has cointegrated arrangements and meanwhile considered essential in terms of forecasting (Hoffman & Rasche, 1996).The IRF predicts that if the shock declines to zero, then the system equations are considered as stable, showing short span converge of variable into its long-term value. Contrary to this, an unstable system would produce a volatile time path away from zero and value will diverge from its short run estimates.

Variance Decomposition (VDC)

The Variance Decomposition (VDC) of the VAR model traces out the proportion of forecast which shows variance in one variable explained by innovations that arise due to itself or due to other variables (Asmah, 2013). Hence, VDC measures the relative importance of fluctuations (nominal or real) in variables under consideration through Choleski Decomposition Method.

Cointegration Test and VECM

Engle and Granger (1987) pointed that if long term cointegration exists between two variables, then there would be a possibility of causality (one way or two way) among the variables. In this regard, VECM is applied to detect the controversial direction of ECEG causality. The VECM forms of the model are given below;

$$\Delta \mathrm{LOGEG}_t = \beta_0 + \sum_{j=1}^{M} \beta_{1j}\, \Delta\mathrm{LOGEG}_{t-j} + \sum_{j=1}^{N} \beta_{2j}\, \Delta\mathrm{EC}_{t-j} + \sum_{j=1}^{0} \beta_{3j}\, \Delta\mathrm{KF}_{t-j} + \sum_{j=1}^{P} \beta_{4j}\, \Delta\mathrm{LP}_{t-j} + \sum_{j=1}^{Q} \beta_{5j}\, \Delta\mathrm{OE}_{t-j} + \sum_{j=1}^{R} \beta_{6j}\, \Delta\mathrm{FD}_{t-j} + \alpha\mathrm{E}_{t-1} + \mu_t \dots\dots\dots\dots (\mathbf{3})$$

$$\Delta\mathrm{EC}_t = \delta_0 + \sum_{j=1}^{M} \delta_{1j}\, \Delta EC_{t-1} + \sum_{j=1}^{N} \delta_{2j}\, \Delta LOGEG_{t-1} + \sum_{j=1}^{O} \delta_{3j}\, \Delta\mathrm{KF}_{t-j} + \sum_{j=1}^{P} \delta_{4j}\, \Delta\mathrm{LP}_{t-j} + \sum_{j=1}^{Q} \delta_{5j}\, \Delta\mathrm{OE}_{t-j} + \sum_{j=1}^{R} \delta_{6j}\, \Delta\mathrm{FD}_{t-j} + \alpha\mathrm{E}_{t-1} + \mu_{2t} \dots\dots\dots\dots (\mathbf{4})$$

$$\Delta\mathrm{KF}_t = \gamma_0 + \sum_{j=1}^{M} \gamma_{1j}\, \Delta KF_{t-1} + \sum_{j=1}^{N} \gamma_{2j}\, \Delta LOGEG_{t-1} + \sum_{j=1}^{O} \gamma_{3j}\, \Delta\mathrm{EC}_{t-j} + \sum_{j=1}^{P} \gamma_{4j}\, \Delta LP_{t-j} + \sum_{j=1}^{Q} \gamma_{5j}\, \Delta\mathrm{OE}_{t-j} + \sum_{j=1}^{R} \gamma_{6j}\, \Delta\mathrm{FD}_{t-j} + +\alpha\mathrm{E}_{t-1} + \mu_{3t} \dots\dots\dots\dots (\mathbf{5})$$

$$\Delta\mathrm{LP}_t = \rho_0 + \sum_{j=1}^{M} \rho_{1j}\, \Delta LP_{t-1} + \sum_{j=1}^{N} \rho_{2j}\, \Delta LOGEG_{t-1} + \sum_{j=1}^{O} \rho_{3j}\, \Delta\mathrm{EC}_{t-j} + \sum_{j=1}^{P} \rho_{4j}\, \Delta\mathrm{KF}_{t-j} + \sum_{j=1}^{Q} \rho_{5j}\, \Delta\mathrm{OE}_{t-j} + \sum_{j=1}^{R} \rho_{6j}\, \Delta\mathrm{FD}_{t-j} + \alpha\mathrm{E}_{t-1} + \mu_{4t} \dots\dots\dots\dots (\mathbf{6})$$

$$\Delta\mathrm{OE}_t = \sigma_0 + \sum_{j=1}^{M} \sigma_{1j}\, \Delta OE_{t-1} + \sum_{j=1}^{N} \sigma_{2j}\, \Delta LOGEG_{t-1} + \sum_{j=1}^{O} \sigma_{3j}\, \Delta\mathrm{EC}_{t-j} + \sum_{j=1}^{P} \sigma_{4j}\, \Delta\mathrm{KF}_{t-j} + \sum_{j=1}^{Q} \sigma_{5j}\, \Delta\mathrm{LP}_{t-j} + \sum_{j=1}^{R} \sigma_{6j}\, \Delta\mathrm{FD}_{t-j} + \alpha\mathrm{E}_{t-1} + \mu_{5t} \dots\dots\dots\dots (\mathbf{7})$$

$$\Delta\mathrm{FD}_t = \alpha_0 + \sum_{j=1}^{M} \alpha_{1j}\, \Delta FD_{t-1} + \sum_{j=1}^{N} \alpha_{2j}\, \Delta LOGEG_{t-1} + \sum_{j=1}^{O} \alpha_{3j}\, \Delta\mathrm{EC}_{t-j} + \sum_{j=1}^{P} \alpha_{4j}\, \Delta\mathrm{KF}_{t-j} + \sum_{j=1}^{Q} \alpha_{5j}\, \Delta\mathrm{LP}_{t-j} + \sum_{j=1}^{R} \alpha_{6j}\, \Delta\mathrm{OE}_{t-j} + \alpha\mathrm{E}_{t-1} + \mu_{6t} \dots\dots\dots\dots (\mathbf{8})$$

Where E_{t-1} represents respective error term, Δ is the first difference and; μ_s are serially uncorrelated random error terms while superscript of the operators shows optimal lag lengths employed in equations.

Estimation Results

It is pertinent to mention here that all estimations have been done through the EViews software (10). It is well elucidated in the table that all variables have been trended and meanwhile are stationary.

Table 2: ADF Unit Root Test

Variables	I(0)		I(1)	
	t-value	p-value	t-value	p-value
LOG(EG)	-1.637231	0.7624	-5.579437	0.0002
EC	-1.467863	0.8266	-6.016301	0.0000
KF	-2.260768	0.4462	-5.245996	0.0005
LP	-3.851361	0.0223	-7.512569	0.0000
OE	-2.352025	0.3989	-5.820766	0.0001
FD	-5.600013	0.0002	-6.625072	0.0000

Table 3 endorses that all values of root's modulus are less than 1 implying that the VAR model of this study satisfies the criteria of stability.

Table 3: VAR Stability Check

Variables	Root	Modulus
EG	0.858703	0.858703
EC	0.431760 - 0.058947i	0.435765
KF	0.431760 + 0.058947i	0.435765
LP	-0.190032 - 0.182683i	0.263601
OE	-0.190032 + 0.182683i	0.263601
FD	0.136289	0.136289

The ADF test statistics and proof of stability check criteria of the VAR model affirm that time series under consideration are stationary (Fang, Jia, Tu, & Sun, 2017). Meanwhile, the Inverse Roots of AR characteristic Polynomial also showed that no root lies outside the circle. Table 4 reveals a lag order selection of the VAR model through divergent selection criterion.

Table 4: Lag Selection for VAR

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-1359.202	NA	3.59e+19	62.05466	62.29796*	62.14488
1	-1291.402	114.0282*	8.60e+18*	60.60918*	62.31227	61.24077*
2	-1269.011	31.55051	1.75e+19	61.22778	64.39067	62.40073
3	-1226.431	48.38627	1.68e+19	60.92870	65.55137	62.64301

Notes:

* = Lag order selected by the criterion

LR = LR: Sequential Modified LR test statistic (each test at 5% level)

FPE = Final Prediction Error

AIC = Akaike Information Criterion

SC = Schwarz Information Criterion

HQ = Hannan-Quinn Information Criterion

As per the maximum selection criterion (LR, FPE, AIC and HQ), the study opted for regressions with one lag. Therefore, LR, FPE, AIC and HQ has been selected. After justifying the model, VAR parameters have been calculated and are shown in table 5. The table explains VAR parameters, and their respective coefficients of the standard deviation with t-statistics.

Table 5: Coefficient Estimations of VAR

	D(LOG(EG))	D(EC)	D(KF)	LP	D(OE)	FD
D(LOG(EG(-1)))	0.210851	152.1824	11.76159	8.998483	1.81E+10	-19.84304
	(0.16792)	(113.517)	(8.97857)	(10.6485)	(2.7E+10)	(27.3913)
	[1.25568]	[1.34061]	[1.30996]	[0.84505]	[0.67231]	[0.72443]
D(EC(-1))	0.000206	-0.010206	0.010647	-0.015603	1.46E+08	0.048455
	(0.00026)	(0.17789)	(0.01407)	(0.01669)	(4.2E+07)	(0.04292)
	[0.78470]	[-0.05737]	[0.75671]	[-0.93507]	[3.45570]	[1.12886]
D(KF(-1))	-9.05E-05	1.549617	0.183879	0.136201	7.43E+08	0.983690
	(0.00307)	(2.07472)	(0.16410)	(0.19462)	(4.9E+08)	(0.50062)
	[-0.02948]	[0.74690]	[1.12054]	[0.69983]	[1.51168]	[1.96494]
LP(-1)	0.001134	-1.867940	0.073879	0.394256	-5.78E+08	0.030883
	(0.00231)	(1.55966)	(0.12336)	(0.14630)	(3.7E+08)	(0.37634)
	[0.49165]	[-1.19766]	[0.59889]	[2.69477]	[-1.56440]	[0.08206]
D(OE(-1))	7.54E-15	-6.17E-10	-3.87E-11	-3.86E-12	-0.233909	1.35E-10
	(9.9E-13)	(6.7E-10)	(5.3E-11)	(6.3E-11)	(0.15850)	(1.6E-10)
	[0.00761]	[-0.92112]	[-0.73055]	[-0.06154]	[-1.47575]	[0.83621]
FD(-1)	-0.000521	-0.086446	-0.037950	0.089676	2.36E+08	0.933578
	(0.00057)	(0.38542)	(0.03048)	(0.03615)	(9.1E+07)	(0.09300)
	[-0.91463]	[-0.22429]	[-1.24490]	[2.48038]	[2.58335]	[10.0385]
C	0.027653	59.85839	-0.941870	13.04452	5.39E+09	2.666420
	(0.06072)	(41.0509)	(3.24688)	(3.85078)	(9.7E+09)	(9.90542)
	[0.45539]	[1.45815]	[-0.29008]	[3.38750]	[0.55478]	[0.26919]
R-squared	0.133068	0.154367	0.208368	0.421211	0.379349	0.797104
Adj. R-squared	-0.000306	0.024270	0.086579	0.332166	0.283864	0.765890

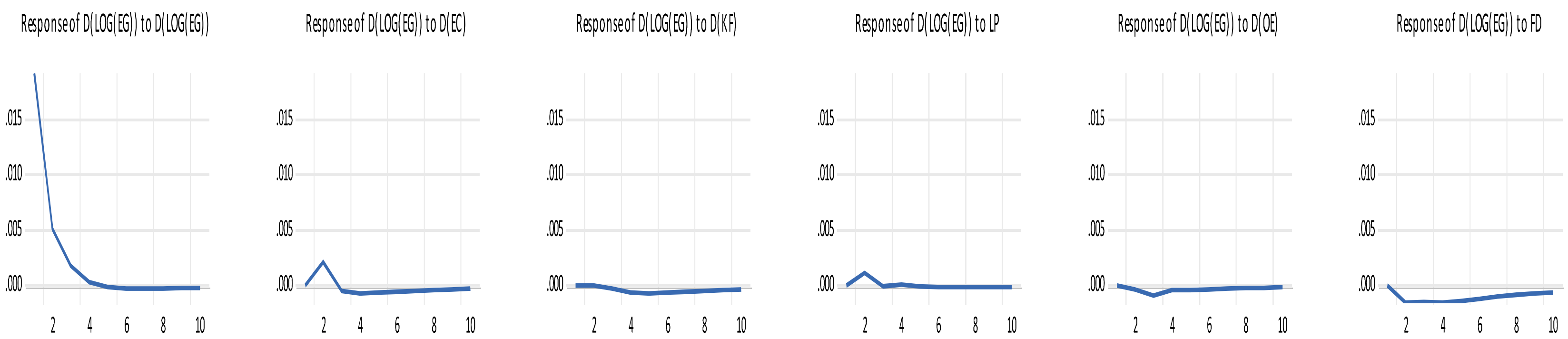
The causality of the variables in table 6 shows the acceptance of neutrality hypothesis between EC and EG. The same is true for the causality running from EG to EC. This finding is compatible with the findings of Sehrawat et al. (2015), Asghar (2008) and Soytas and Sari (2003). This could be due to the two prime factors in the context of Pakistan. First, the traditional energy conservative policies of Pakistan are found unsuccessful in determining the economic growth (Shahbaz et al. 2012). Second, the severe power outages and slow industrial growth had surged shut downs of productive industrial and commercial units, increasing unemployment. This in turn enhanced the process of deindustrialization over the last two decades (Yasmeen & Qamar, 2013).

The outcomes of VAR causality showed a deviation from the existing wide-ranging literature that assured one- or two-way causality between EC and EG. There is also a weak evidence of causality in the short run among other variables except of one-way causality between LP and FD; and between EC and OE. These reasonable findings suggest that there is still a need to introduce comprehensive policy measures in Pakistan interlinking the energy, growth, trade and financial development for sustainable growth (Khan, Jam, Shahbaz, & Mamun, 2018).

Table 6: VAR Granger Causality/Block Exogeneity Tests

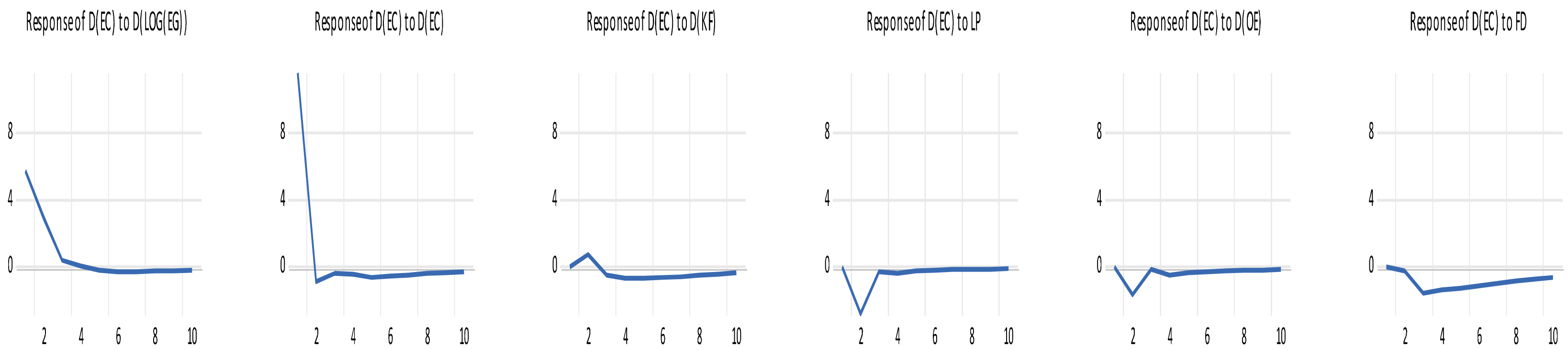
Excluded	Chi-squ.	Prob.	Neutrality Hypothesis
Dependent Variable: D(LOG(EG))			
D(EC)	0.615761	0.4326	Accepted
D(KF)	0.000869	0.9765	Accepted
LP	0.241719	0.6230	Accepted
D(OE)	5.79E-05	0.9939	Accepted
FD	0.836548	0.3604	Accepted
Dependent Variable: D(EC)			
D(LOG(EG))	1.797229	0.1800	Accepted
D(KF)	0.557867	0.4551	Accepted
LP	1.434390	0.2310	Accepted
D(OE)	0.848467	0.3570	Accepted
FD	0.050307	0.8225	Accepted
Dependent Variable: D(KF)			
D(LOG(EG))	1.716003	0.1902	Accepted
D(EC)	0.572604	0.4492	Accepted
LP	0.358667	0.5492	Accepted
D(OE)	0.533701	0.4651	Accepted
FD	1.549769	0.2132	Accepted
Dependent Variable: LP			
D(LOG(EG))	0.714102	0.3981	Accepted
D(EC)	0.874356	0.3498	Accepted
D(KF)	0.489768	0.4840	Accepted
D(OE)	0.003787	0.9509	Accepted
FD	6.152281	0.0131	Rejected
Dependent Variable: D(OE)			
D(LOG(EG))	0.451994	0.5014	Accepted
D(EC)	11.94188	0.0005	Rejected
D(KF)	2.285191	0.1306	Accepted
LP	2.447350	0.1177	Accepted
FD	6.673699	0.0098	Accepted
Dependent Variable: FD			
D(LOG(EG))	0.524795	0.4688	Accepted
D(EC)	1.274320	0.2590	Accepted
D(KF)	3.860976	0.0494	Accepted
LP	0.006734	0.9346	Accepted
D(OE)	0.699242	0.4030	Accepted

Figure 4: Response of EG to Cholesky one S.D (d.f adjusted) Innovations



Note: Generated from Eviews Software

Figure 5: Response of EC to Cholesky one S.D (d.f adjusted) Innovations



Note: Generated from Eviews Software

Figure 4 and 5 displays the impulse response functions of the EC and EG to one standard deviation structural shocks. The first graph in figure 4 shows that the response of EG to its own shocks is contemporaneously positive and strong for initial periods and approache zero at the end of the period. The response of EG to a shock in EC shows no impact in initial periods while the response will converge over the time horizons. This is also consistent with the causality outcomes of this study. Besides, the response of EG to the shock in KF; and LP are found stable while FD and OE have displayed slightly negative deviation from its stability. The IRF of the EC in figure 5 positively responds to its own shocks in its initial periods and latterly negative response and movement towards stability is observed. The response of EC for EG has a positive movement in initial periods with slight negative effect in subsequent periods, however, the IRF converges to its stability at the end periods. Additionally, KF is less responsive while LP, OE, and FD have experienced negative yet stable responses.

The results of the VDC estimates of the endogenous variable of EG from VAR are presented in table 7 at various quarters. The exercise explained that that the percentage of variance explained by own shock for EG originated from 97 percent in the second quarter and continues decreasing up to 92 percent in the 10^{th} period.

Table 7: VDC of EG from VAR

Period	S.E.	D(LOG(EG))	D(EC)	D(KF)	LP	D(OE)	FD
1	0.020245	100.0000	0.000000	0.000000	0.000000	0.000000	0.000000
2	0.021193	96.98096	1.344841	0.064293	0.162351	0.193793	1.253762
3	0.021450	95.29003	1.417780	0.102306	0.167342	0.635900	2.386645
4	0.021629	93.73059	1.750607	0.226358	0.167110	0.750222	3.375113
5	0.021741	92.76686	1.919948	0.345221	0.168370	0.829665	3.969939
6	0.021810	92.19126	2.052733	0.418965	0.169229	0.869798	4.298015
7	0.021848	91.87857	2.126526	0.462527	0.170454	0.889200	4.472722
8	0.021868	91.71593	2.165787	0.485830	0.171320	0.899245	4.561892
9	0.021878	91.63302	2.186469	0.497784	0.171907	0.904202	4.606621
10	0.021883	91.59167	2.196903	0.503777	0.172281	0.906653	4.628719

This indicates that economic growth is highly endogenous with the remaining factors accounting for the volatility in the economic growth to varying degrees. Considering the fraction of economic growth forecast error variance attributable to variations in EC, it initiates with 13 percent at second period and then declines in the third quarter by the end of the 10^{th} quarter up to 21 percent. Turning to the VDC estimates of electricity consumption in table 8, it shows that EC starts declining from 73 percent in the second period and the pattern continues till the 10^{th} period with a decrease of 68 percent.

Table 8: VDC of EC from VAR

Period	S.E.	D(LOG(EG))	D(EC)	D(KF)	LP	D(OE)	FD
1	13.45021	19.11808	80.88192	0.000000	0.000000	0.000000	0.000000
2	14.16329	21.64756	72.94480	0.418902	3.594809	1.196524	0.197405
3	14.33567	21.23103	71.51232	0.550343	3.800076	1.178008	1.728218
4	14.46761	20.85167	70.27259	0.800937	3.878743	1.314716	2.881352
5	14.57369	20.55661	69.51709	0.978490	3.882458	1.378656	3.686698

6	14.64206	20.38176	69.03062	1.112806	3.860392	1.413766	4.200655
7	14.68346	20.28037	68.74832	1.192818	3.843236	1.437502	4.497758
8	14.70760	20.22338	68.59033	1.238513	3.831690	1.450494	4.665598
9	14.72105	20.19229	68.50351	1.263822	3.824864	1.457878	4.757628
10	14.72837	20.17557	68.45705	1.277359	3.821070	1.461966	4.806983

The endogeneity of the electricity consumption is explained in table 8 through economic growth with 21 percent and 20 percent for the second and last period respectively. Henceforth, like economic growth, the VDC of EC exercise also effectively demonstrates the momentous role played by the other variables of the model. In the next set of estimation, the dynamic perspective has been plugged through Cointegration and VECM methods. The Johansen cointegration method has been estimated as none of the series are integrated at second order.

Table 9: Johansen's Cointegration Estimates

No. of CE(s)	Eigenvalue	Trace Statistic	Critical Value	Prob.
None *	0.578239	113.8756	95.75366	0.0016
At most 1 *	0.465445	75.02639	69.81889	0.0181
At most 2	0.393846	46.84195	47.85613	0.0621
At most 3	0.333009	24.31401	29.79707	0.1875
At most 4	0.107168	6.089987	15.49471	0.6849
At most 5	0.021737	0.988945	3.841466	0.3200

The estimates of the Johansen cointegration in table 9 indicate that the series of the VAR model possess at least two cointegrating associations in the long run. This result validated the dynamic association between the variables of the model.

Table 10: VECM Estimates

Error Correction	**D(LOG (EG),2)**	**D(EC,2)**	**D(KF,2)**	**D(LP)**	**D(TO,2)**	**D(FD)**
CointEq1	-0.108562	202.3172	-15.31324	12.22487	3.29E+10	-22.61736
	(0.10085)	(76.5725)	(5.85389)	(6.36581)	(1.7E+10)	(16.8750)
	[-1.07644]	[2.64217]	[-2.61591]	[1.92039]	[1.88497]	[-1.34029]
D(LOG(EG (-1)),2)	-0.446080	27.04273	20.29255	-11.38359	3.47E+09	-12.70157
	(0.14371)	(109.109)	(8.34126)	(9.07070)	(2.5E+10)	(24.0453)
	[-3.10413]	[0.24785]	[2.43279]	[-1.25498]	[0.13926]	[-0.52824]
D(EC(-1),2)	6.37E-05	-0.307766	-0.006204	0.002604	1.45E+08	0.013362
	(0.00019)	(0.14232)	(0.01088)	(0.01183)	(3.2E+07)	(0.03136)
	[0.33968]	[-2.16245]	[-0.57019]	[0.22004]	[4.46221]	[0.42603]
D(KF(-1),2)	0.001010	-0.161232	-0.099087	-0.144341	2599733.	0.685178
	(0.00275)	(2.08617)	(0.15949)	(0.17343)	(4.8E+08)	(0.45975)
	[0.36766]	[-0.07729]	[-0.62129]	[-0.83226]	[0.00546]	[1.49033]
D(LP(-1))	-0.002358	0.519371	-0.179436	-0.407750	-7.63E+08	-0.210684

	(0.00255)	(1.93962)	(0.14828)	(0.16125)	(4.4E+08)	(0.42745)
	[-0.92298]	[0.26777]	[-1.21010]	[-2.52869]	[-1.72287]	[-0.49288]
D(TO(-1),2)	-7.51E-13	5.84E-10	-1.33E-10	1.20E-10	-0.268088	-1.73E-10
	(9.3E-13)	(7.1E-10)	(5.4E-11)	(5.9E-11)	(0.16160)	(1.6E-10)
	[-0.80497]	[0.82538]	[-2.46589]	[2.03261]	[-1.65893]	[-1.10939]
D(FD(-1))	0.000406	-0.624320	-0.125906	-0.024508	11361193	0.280617
	(0.00093)	(0.70608)	(0.05398)	(0.05870)	(1.6E+08)	(0.15561)
	[0.43657]	[-0.88421]	[-2.33250]	[-0.41751]	[0.07050]	[1.80339]
C	0.000213	-0.033436	0.071424	0.053513	2.78E+08	0.243192
	(0.00296)	(2.24644)	(0.17174)	(0.18676)	(5.1E+08)	(0.49507)
	[0.07184]	[-0.01488]	[0.41589]	[0.28654]	[0.54202]	[0.49123]

Table 9 explains the VECM estimates of the VAR model confirming the results of block exogeneity tests with statistically insignificant value of t-statistic (1.07). These results are inconsistent with the findings of panel study of Razzaqi et al. (2011) in the context of Pakistan.

Discussion

The econometric findings of the VAR model, IRF, VDC and VECM require plausible explanations in the context of both CPEC and ground realities of the electricity sector in Pakistan. Therefore, the discussion on electricity sector through the lenses of internal and external factors have been elaborated keeping in view the reforms of the new economy of Pakistan.

Internal Bottlenecks

According to the official website of CPEC (Pakistan), 15 power projects of CPEC are planned to meet the supply target of 11,110 MW out of which 7 projects are in operational position. Meanwhile, 6 projects are still in progress and are expected to enhance the generation capacity up to 6,910 MW. The status of remaining two projects is yet to be determined. The detail shows that CPEC power component is more focused towards electricity generation ignoring the needs of parallel distribution and transmission lines. Turning to the use of input of power projects, CPEC stressed on indigenous, renewable and clean resources, including coal (local and imported), solar, wind and hydel. On the other side of the story, use of imported coal in major projects is supposed to increase the cost exerting redundant burden on total outlays with transportation challenges. Further, despite the increasing trend in the use of renewable energy (solar), there are yet no prospects for such markets at domestic level in Pakistan. This would tend to induce more imports and deviations from fuel-based energy and thus calls for generating opportunities for the new energy markets (renewable) through complementary policy initiatives (Kazmi, Rehman, & Nasrullah, 2016). The other conspicuous feature of CPEC power projects is the financing through Independent Power Producers (IPPs) while these IPPs are responsible to pay the capacity payments and security costs during the operational period. In this scenario, delay in developing distribution lines would generate more pressure on circular debt (Ali & Badar, 2010). This would further spill over to the whole power supply chain, affecting payments and tariffs to domestic and commercial consumers. The other major bottleneck that could restrain the productivity of CPEC power projects is the insufficient capacity building and analytical support from China in the power sector which has yet not been traced out. Further, there is no plan to deal with peak oriented consumption of electricity that raises a quandary regarding the induction of additional power supply in Pakistan. Correspondingly, a declining share of electricity consumption by manufacturing sector would further exert devastated outcomes on the other sectors of the economy (Yasmeen & Qamar, 2013). Thus, the timely completion of Special Economic Zones (SEZs) is crucial to recuperate the industrial units specifically the large-scale sector deprived of deindustrialization.

External Bottlenecks

First and foremost, the existing installed capacity and upcoming increase in electricity generation is expected to overburden the transmission and distribution set ups as these arrangements are not only contracted but also an impediment to the financial sustainability of the power sector. According to the report of Asian Development Bank (ADB) of 2019, it is very urgent to overcome this issue as the probability of unscheduled outages and system failures will be surged due to on-stream electricity generation over the next three years. Second, this new capacity will substantially induce the volume of sales that will further increase circular debt putting more pressure on aggregate losses. This will further enhance the debt (unpaid) which travels from distribution companies (DISCOs) to generation companies (GENCOs) and fuel suppliers (Ali & Badar, 2010). Third, State Owned enterprises (SOEs) in Pakistan always show reluctance in improving their performance (financial and operational) while Independent Power Producers (IPPs) are also in the queue due to delayed disbursements from Central Power Purchasing Agency Guarantee Limited (CPPA-G). Fourth, the trap of circular debt initiates at the DISCOs that are short of revenues and reluctant to cover capital and operating costs. This happens due to setting tariffs below cost, and partial charging of electricity bills. Meanwhile, IPPs claim borrowing to meet their capital requirements further surges their operating costs despite getting government incentives (guarantees, profit margins etc.). Consequently, IPPs transmute the circular debt throughout the supply chain worsening payment schedules. Fifth, lack of coordination between inter and intra agencies of the supply chain hinders the process of solving the problem (ADB, 2019). For instance, department of sub-transmission at DISCO have limited communication with the handling departments of medium and low voltage systems (ADB, 2019). Last but not the least, the political economy of new Pakistan has to overcome the status quo factors restraining transparency and reforms in the power sector.

On the whole, a more comprehensive analysis is missing at both internal and external levels, which demands long term planning for power infrastructure through its advancement. This could conveniently be attained through commercialization and implications of the effective and defined policy appraisals and plans.

Power Sector Reforms of New Pakistan: A Way Forward for CPEC

Considering the recent plan of the power sector, the PES (2018-19) highlighted vibrant reforms for the sector that are supposed to take into account for better services and provision of electricity. In this regard, an immense stress has been provided to develop an **"Integrated Energy Plan"** which basically documents projections of electricity demand for the emerging energy generation in Pakistan. The focus of the plan revolves around energy mix and renewable resource with a detailed planning of the power sector. This will induce to address the issues of circular debt and capacity payments with evidence-based policy interventions. Apart from this planning side, there is also a dire need to harmonize the public levers and market forces of the power sector. On this perspective, the recent government is developing and incentivizing the business models of Energy Services Companies (ESCO) and Sustainable Energy Utility (SEU) to strengthen market forces of the power sector. The government is also working on the idea to design and process policies to transform the single buyer models into competitive market structures. Besides, the segregation of DISCOs on regional bases is also under consideration that will release the pressure on distribution chain of the electricity sector. Similarly, the efforts for closer regulatory cooperation between authorities of power and petroleum are also in the pipeline as it is crucial for the advancement of energy economics and democratization of the electricity sector. In the nutshell, the effective implementation of these initiatives would address the issues of the CPEC power projects more appropriately and more abruptly.

Conclusion

This study is an endeavor to revisit the ECEG model in lieu of the productive shock of CPEC for Pakistan. The empirical evidence has been developed through employing VAR model in compliance with IRF and VDC analyses. The estimation outcomes revealed that there exists no short run causal relationship among the variables of the model while estimates also affirmed a long run cointegration in the model. These findings endorsed a neutrality hypothesis which points out that energy conservation policies are ineffective to pronounce the ECEG in Pakistan. The IRF and VDC exercises approved that there exists stable association between electricity consumption and economic growth. After the econometric estimations, we endeavored to integrate the empirical findings through indicating the relevant internal and external bottlenecks. In the nutshell, it is presumed that failure to address issues would not only further deteriorate the prevailing scenario yet also crowd-out the investment of CPEC in the power sector. Further, lack of anticipation in determining the actual demand and supply gaps in the power sector and forecasting and planning for the future is the other weak area. At this stage of CPEC, upgradation of existing distribution lines and new set ups are essential. It is thus recommended to revise the ECEG model for the new economy of Pakistan keeping in view the revival of the industrial sector to induct the excess supply of electricity in order to remove the inefficiencies in the power sector.

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Appendix A

Table A1: Description of Variables

Variable	Abbreviation	Proxy	Measurement	Data Source
Economic Growth	EG	GDP growth	Real GDP (constant prices)	World Bank Indicators
Electricity Consumption	EC	______	Kilowatt Hour (kwh) per capita	World Bank Indicators
Capital Formation	KF	Gross fixed capital formation	% of GDP	World Bank Indicators
Labor Participation	LP	Labor force participation	% of working age population	Handbook of Statistics & Labor force Survey
Openness of Economy	OE	Trade to GDP Ratio	Exports + Imports/ GDP	World Bank Indicators
Financial Development	FD	Broad Money	% of GDP	World Bank Indicators

Source: Tabulated by Authors

Table A2: Residual Serial Correlation LM Tests

Lag	LRE* stat.	df	Prob.	Rao F-stat	df	Prob.
1	34.32672	36	0.5483	0.949562	(36, 125.7)	0.5566
2	85.67389	72	0.1294	1.229534	(72, 125.5)	0.1555
3	118.5470	108	0.2295	1.082759	(108, 98.9)	0.3447
4	181.8047	144	0.0180	1.270367	(144, 66.3)	0.1370

Source: Estimated by Authors

Table A3: VAR Residual Heteroskedasticity Tests (Levels and Squares)

Chi-sq	df	Prob.
269.6997	252	0.2118

Source: Estimated by Authors

Table A4: VECM Residual Serial Correlation LM Tests

Lag	LRE* stat.	df	Prob.	Rao F-stat	df	Prob.
1	28.49422	36	0.8091	0.770908	(36, 121.3)	0.8144
2	65.70097	72	0.6862	0.879811	(72, 120.1)	0.7207

Source: Estimate by Authors

Table A5: VECM Residual Normality Tests

Component	Jarque-Bera	df	Prob.
LOGEG	0.406891	2	0.8159
EC	9.636324	2	0.0081
KF	0.368343	2	0.8318
LP	0.713557	2	0.6999
OE	2.704929	2	0.2586
FD	1.005982	2	0.6047
Joint	14.83603	12	0.2505

Source: Estimated by Authors

Table A6: VECM Residual Heteroskedasticity Tests (Levels and Squares)

Chi-sq	df	Prob.
298.5662	294	0.4150

Source: Estimated by Author

Appendix B

Figure B1: Response of KF to Cholesky one S.D (d.f adjusted) Innovations

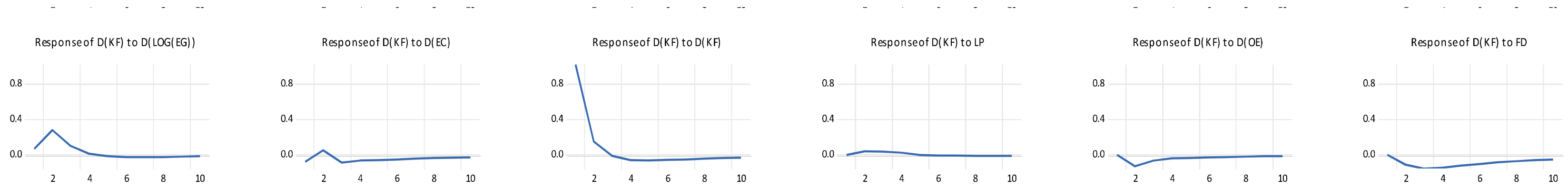

Figure B2: Response of LP to Cholesky one S.D (d.f adjusted) Innovations

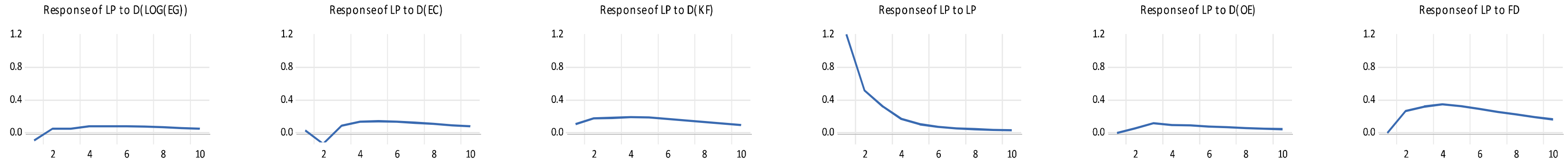

Figure B3: Response of OE to Cholesky one S.D (d.f adjusted) Innovations

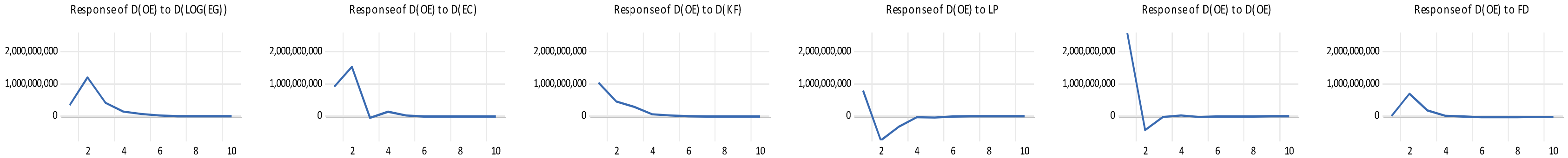

Figure B4: Response of FD to Cholesky one S.D (d.f adjusted) Innovations