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Investigating the Interactive Role of Demand Side Factors Potentially Responsible for Energy Crisis in Pakistan

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ABSTRACT

This paper attempts to investigate the dynamic relationship among Energy Consumption (E), Financial System Development (F), Industrailization (I), Agriculture Development (A) and Economic Growth (Y) in case of Pakistan for the period 1971-2018 by using cointegration approach. After confirming the level of stationarity, the presence of long run relationship among the series was tested through newly developed combined cointegration approach in addition to ARDL bound testing with structural break dummy. The short run and long run parameter coefficients were estimated by unrestricted error correction model (UECM) because all the series are found stationary at 1st difference I(1) and sufficient evidence of cointegration. Finally, the direction of causality among the considered variables was achieved through Granger causality test within the framework of VECM. The long run parameter coefficient estimates by UECM indicate that financial development, industrialization, economic growth and decrease in agricultural contribution to GDP induce electricity consumption in Pakistan. We also found that a long-run unidirectional causality is running from the economic growth to electricity consumption which favors the electricity conservation hypothesis in case of Pakistan. The causality running from the electricity consumption to agriculture output coupled with negative parameter coefficient value suggests that electric power deficit is responsible for hampering the agricultural growth in Pakistan. The study suggests that electricity conservation policy in addition to prudent rationing of electric power among the various sectors may greatly contribute to minimize the adverse effects of energy crisis in Pakistan.

Keywords: Financial Development, Industrialization, Agriculture Development, Economic Growth, Energy Crises, Pakistan
JEL Classifications: Q43, O14, Q18, F43, G00

1. INTRODUCTION

Energy is undoubtedly a driver of economic growth and a crucial input to nearly every good and service produced in the economy. However, energy is a capital-intensive sector which requires substantial investments and long hatching time. Therefore, a prudent energy policy is crucial for the sustainable and balanced economic growth of a country. According to the International Energy Agency (2021) cumulative global energy investment is set to rise 1.9 trillion which is nearly 10% higher than 2020. This unprecedented 10% increase is a reversal to the all-time low caused by pandemic (World Energy Investment, 2021). The significant growth in the investment in energy sector is result of increased energy demand which is estimated to be 4.6% in 2021. This rapidly increasing energy demand would be one of the biggest challenges confronting the world(Khan and Ahmed, 2008).

The relationship between energy consumption, economic growth and related factors is well-researched in the literature. However, there is a lack of consensus in the extant literature over the direction of causality between energy consumption and economic growth patterns across countries. The inconsistency of empirical evidence regarding the direction of causality may be attributed to the selection of variables, econometric approaches, period of the study, and specification of the model. Karanfil (2009) contended that the replication of energy-growth nexus studies in different economies produces conflicting and mixed results which merely serve the purpose of policy makers. Thus, it is essential to undertake specific research studies by considering the specific challenges confronting the economy. We argue that a country's peculiar economic development pattern and institutional differences associated with the level of economic development affect the energy-growth nexus in different ways. Therefore, it is important to scan the interactive role of factors affecting the energy consumption patterns with reference to the particular economic challenges confronting an economy to offer viable solutions to the policy makers.

During the last few decades many developing countries have experienced a manifold growth in electricity demand as a result of economic development. However, few countries like Pakistan failed to expand the electric power generation capacity in anticipation to growing demand for electricity, resultantly suffering acute energy crises. The energy crises of Pakistan are deep rooted and multifaceted with numerous possible solutions. As a short-term measure, the government of Pakistan prioritized the household sector over industrial sector for electric power supply to avoid the public demonstrations and agitation. The temporary relief to household sector at the cost of economic growth has worsened the crisis. This panic action of the government has adversely affected the industrial sector and agricultural sector. Aziz et al. (2010) estimated a loss of $3.8 billion to the economy in 2009—about 2.5 percent of the gross domestic product (GDP) as a result of power shortages in the industrial sector alone. Half a million jobs and exports worth $1.3 billion were lost. Many industrial units that could not afford the private power generation were either shut down or moved to other countries like Bangladesh, Malaysia and Middle Eastern countries, resultantly many people lost their jobs. Private power generation companies were unable to produce at the full capacity due to financial distress resulting from non-collection of revenues and increased level of circular debt.

A variety of factors is generally considered responsible for the present energy crisis in Pakistan, for instance, circular debt, lack of political will, lack of good governance, theft and non-payment of electricity bills, line losses, and deteriorated transmission infrastructure. Pakistan is facing energy shortage since very beginning, however, the energy crises start worsening after the year 2007 because the power generation could not be proportionately increased to cater the growing energy demand stemming from increased economic activity. The role of liberal credit policies during 2002 to 2007 in energy crises cannot be overlooked. The irrational exuberance in car financing and other domestic loans by banks for energy consuming household items such as refrigerators, air conditioners, and televisions significantly increased the energy demand.

Pakistan is basically an agrarian economy; agriculture sector contributed 19.2 percent in GDP in 2020-21 and is a source of livelihood of 38.5 percent of the labor force (latest; Pakistan Economics Survey 2020-21). The agriculture sector is third biggest consumer of energy after household and industry (Economic Survey of Pakistan 2020-2021). The share of energy consumption in agriculture has continuously decreased from 19 percent and 14 percent in 1972 to 11 percent and 1 percent in 2005 in the case of electricity and petroleum respectively (Mushtaq et al., 2007). Agriculture sector is a huge supporter to industrial sector because it provides various inputs/raw materials to industries such as cotton, sugarcane etc. For example, the textile industry is the biggest industry in Pakistan, consume a large volume of cotton which in turn is used to produce 55% of Pakistan's textile exports. Thus, a strong link exists between agriculture and industrial sector in Pakistan. Low productivity in agriculture due to energy deficiency or any other reasons will greatly affect the industrial output. Industrial sector is the biggest consumer of energy in Pakistan. The growth rate of the large-scale manufacturing has been dropped from 18.8% in 2004-2005 to −6.1% in fiscal year 2009 due to severe energy shortages (Pakistan Economic Survey 2009-10 and 2020-21). After year 2009 LSM start recovering due to the government's efforts to provide energy to the industry. The Large scale manufacturing sector reported steady growth until FY2019 when pandemic badly affected the world economy. The similar trend of low production rate has been seen in most of the small-scale manufacturing industries (Qazi et al., 2012). Thus, the energy deficiency affects the industrial sector in two ways, a direct effect as energy is considered as a factor of production. Secondly, low production of agriculture due to energy deficiency also affect industrial sector.

It has been well recognized that a long run relationship of financial system, industrial sector and agriculture development, economic growth exist in a country. However, the direction of causality remains an open research question in most of the developing economies. Therefore, an investigation into the interactive relationship and direction of causality between financial system development, industrialization and agriculture development in a particular economic environment may greatly improve our understanding and provide insights to the policy makers.

This study contributes to the literature in two novel ways. First, a pioneering study to investigate the dynamic relationship among the demand-side macroeconomic factors potentially responsible for the energy crisis in Pakistan and the discussions on the results are carried out with reference to the economic challenges amid energy crises. Moreover, this is the first study, with reference to Pakistan, which considered financial development, industrial growth, agricultural development and economic growth into the energy-growth nexus by using the longest available data from 1971 to 2018 and contemporary econometric approaches such as Bayer and Hanck (2013) combined cointegration. Second, methodologically this study has four-fold contribution to the literature; (i) the time series properties of the variables were tested by using Zaviot and Andrews unit root test in presence of structural breaks in addition to standard unit root tests such as Augmented Dicky Fuller (ADF) and Philips-Perron (PP), (ii) the presence of long run relationship is confirmed by using combined cointegration approach newly proposed by Bayer and Hanck (2013) and as robustness check breaks was also applied Auto Regressive Distributed Lag (ARDL) bound testing approach in presence of structural breaks, (iii) the short run and long-run elasticity estimates were achieved by unrestricted Vector Auto Regressive (VAR) model, (iv) the short run and long run causal relationship was tested by Granger cause approach within the framework of Vector Error Correction Model (VECM).

The study is limited to the macroeconomic variables which directly impact economic growth such as financial development, industrial development and agriculture. The other demand side macroeconomic variables such housing and population growth, income growth, livening standard and weather are not included in this study.

This paper attempts to investigate the interactive role of demand side factors such as financial development, industrialization, agricultural development and economic growth in electricity consumption in Pakistan using cointegration methodology over the period 1971 to 2018. The empirical findings show that a long run relationship exists among the model variables. Industrialization, financial development and economic growth induce energy consumption in long run. The decrease in the contribution of agricultural sector to GDP also affect the electricity consumption positively. The long run unidirectional causality running from economic growth to electricity consumption validates the conservation hypothesis in the long run, in case of electricity consumption in Pakistan.

The rest of the paper has been organized as follows; section 2 presents the brief account of existing literature related to our topic, in section 3 we have described the data collection and empirical framework, the results have been discussed in section 4 and section 5 concludes the paper with some policy implications.

2. REVIEW OF THE LITERATURE

It has become a stylized fact that energy consumption is crucial for the economic growth of a country. However, the empirical evidence about the direction of causality between energy consumption and economic growth show mixed and conflicting results. In a comprehensive survey of literature Payne (2010) suggested that the empirical inquiries into the energy-growth nexus may greatly contribute to the policy formulation if the direction of causality is established between energy consumption and economic growth. Squalli (2007) proposed the following four testable hypotheses with great policy implications for energy-growth nexus; (i) growth hypothesis, postulate the unidirectional causality running from the energy consumption to growth (ii) conservation hypothesis, suggesting the unidirectional causality running from the economic growth to energy consumption, (iii) neutrality hypothesis, suggesting no causal relation between energy consumption and economic growth, (iv) feedback hypothesis, which suggests a bidirectional causal relation between energy consumption and economic growth. If the causality is running from the energy consumption to the economic growth, any energy conservation policy may adversely affect the economic growth and if the unidirectional causality is running from the economic growth to energy consumption, the energy conservation policy may contribute to the reduction of CO2 emissions without compromising the economic growth (Ozturk, 2010; Shahbaz and Lean, 2012). Similarly, the relationship between energy consumption and other variables (determinants economic growth) can be tested in light of similar four hypotheses.

2.1. Relationship between Economic Growth and Energy Consumption

Beginning with the seminal work of Kraft and Kraft (1978), there has been growing number of studies that have investigated the energy consumption and economic growth nexus. The empirical results pose a great deal of controversies for the direction of causality between economic growth and energy consumption (e.g., Asafu-Adjaye, 2000; Aqeel and But, 2001; Ang, 2008; Ozturk and Acaravci, 2010; Wang et al., 2011; Apergis and Payne, 2010; Arouri et al., 2012; Choudhray et al., 2012; Menegaki, 2019; Emir and Bekun, 2019; Žiković et al., 2020; Cheng et al., 2021). This contradiction in the energy economics literature may be attributed to the variety of econometric approaches used to study the energy-growth nexus in addition to the institutional differences associated with the level of economic development of a country (Shahbaz and Lean, 2012). The ambiguity stemming from the inconsistent research findings deteriorate the value of research for policy formulation (Shahbaz et al., 2013).

A variety of control variables is used to study the energy-growth nexus depending on the research objectives. The inclusion of financial development, industrial development and agriculture development in this study enables us to highlight the role of the demand side factors in the present energy crises of Pakistan. Karanfil (2008) suggested that the relationship between official GDP and energy consumption may not produce reliable results in developing economies due to unrecorded economic activities. Therefore, the interactive role of determinates of economic growth may provide better insights into the issue under the consideration.

2.2. Relationship between Financial Development and Energy Consumption

A sound financial system by efficient channeling of funds from lenders to borrowers and effective placement of capital in the progressive and innovative investment projects may greatly contribute to the economic development of a country (Siva and Rao, 2018; Nyasha and Odhiambo, 2018; Asteriou and Spanos, 2019). Financial system development plays an important role in economic growth of a country by generating positive economic activity through attracting FDI (Frankel and Romer, 1999). However, financial development with poor regulatory environment and inefficient funds transmission mechanism may potentially harm the economic growth in transition economies (De Gregorio and Guidotti, 1995; Hassan et al., 2011). The financial liberalization without considering the dynamics of the economy may adversely affect the economic growth (Arestis and Demetriades, 1997; Levine, 2001; Tamazian et al., 2009; Stiglitz, 2010).

During last few decades, many transition economies have undergone structural transformation and shifting from planned to market economy. A rapid increase in the energy demand as the result of financial development, industrialization, and infrastructure expansion have been recorded during the period of the transformational stage. Sadorsky (2010) confirmed the impact of financial system development on the energy consumption in 22 emerging economies by applying Generalized Moment Method on the capital market data. Sadorsky (2011) also found similar results in the case of Central and Eastern European countries. Al-Mulali and Sab (2012) by applying the panel data methodologies found a significant and positive relationship between energy consumption and financial system developments. Shahbaz and Lean (2012) investigated the role of financial development and industrialization in energy consumption level in case of Tunisia and confirmed the long run bidirectional causality between financial system development and energy consumption as well as between industrialization and energy consumption. Islam et al. (2013) also confirmed the long-run relationship between energy consumption and financial development in Malaysia by using VECM approach. Shahbaz et al. (2013) found empirical evidence to validate the long-run relationship between energy consumption and financial development. Çoban and Topcu (2013) reported a positive link between energy consumption and financial development in the case of UAE. Similarly, Salahuddin et al. (2015) also confirmed the positive relationship between financial development and energy consumption in Gulf Cooperation Council (GCC) countries. However, in 27 EU countries, no significant relationship is detected (Çoban and Topcu, 2013). Tang and Tan (2014) reported the unidirectional causality from energy consumption to financial development in the case of Malaysia. Similar results of unidirectional causality between money supply and energy consumption was found in case of Pakistan (Kakar et al., 2011). ZEREN and KOC (2014) conducted study for newly industrialized 7 Countries spanning the period 1971 till 2010 and found unidirectional causality from energy consumption to financial developments in Philippines and two-way causality occurred for India, Turkey and Thailand.

2.3. Relationship between Industrial Development and Energy Consumption

According to the Industrial Development Report 2011 (UNIDO, 2011) industry is the largest energy user worldwide, consume about 31 percent of world energy since the early 1990s. In developed economies, industry consume only 24 percent of energy (0.8 Gtoe) while in developing economies, energy consumption in industry is much faster and remains the main user of energy (1.7 Gtoe). The industrial sector of Pakistan is the largest sector contributes 20.30% to the GDP (Pakistan Economic Survey, 2020-21). On average industrial sector consumed 37.3% of energy which is higher from all sectors (Khan and Ahmed, 2008). Theoretically, a strong relationship between industrial growth and energy consumption exists but is less focused in the literature and there is lack of empirical evidence in case of Pakistan. Therefore, Shahbaz et al. (2013) suggested the inclusion of industrialization in energy-growth nexus for a better understanding. Exploring the relationship between industrial growth and energy consumption is very important because the “use of energy in industry affects every single personally citizen through the cost of goods and services, the quality of manufactured products, the strength of the economy, and the availability of jobs” (National Academy of Sciences, 2008). A case study of Pakistan conducted by Qazi et al. (2012), a unidirectional causality was identified which is running from electricity consumption to industrial output. Similarly, a uni-directional causality running from electricity consumption and gas consumption to industrial GDP in long-run is identified in Tunisia (Abid et al., 2012).

2.4. Relationship between Agriculture Development and Energy Consumption

Energy is a key input for agriculture development and the dependency of agriculture on electricity consumption in Pakistan has increased over time, while power generation has not kept up with demand (Ahmed and Zeshan, 2014). In Pakistan, the relationship between agriculture development and energy consumption has been less focused and is not clear in literature because this relationship has been changed due to rising energy prices and changes in agriculture policies. Traditionally, the relationship has been one-way, with agriculture using energy products as an input in production (Beckman et al., 2013). Moreover, during the past decade, the energy sector’s use of agricultural products as renewable-fuel feed stocks and the use solar energy has increased substantially. Although, it is well known that a strong correlation exists between agriculture development and energy consumption. However, no empirical evidence is available in Pakistan to show the direction of causality which needs to be investigated which may provide an insight for the policy makers.

3. METHODOLOGY

To investigate the dynamic relationship among energy consumption, financial development, industrialization, agricultural development and economic growth in Pakistan, we specified the log-linear model. The empirical relationship among the selected series is represented in the following general form.

$$\ln E_{t'} = \alpha+\beta F_{t+}\beta I_t+ \beta A_t+\beta Y_t+\mathcal{E}_t \quad (1)$$

Where E stands for logarithmic per capita electric power consumption in kWh, F is the logarithmic share of domestic credit by private sector in GDP as a proxy for financial development, I is logarithmic contribution of industry value added in the GDP as a proxy for industrialization, A is logarithmic contribution of agricultural value added in the GDP as proxy for agricultural development and Y is economic growth measured as logarithmic per capita real GDP. The data of these variables for the period 1971 to 2018 is taken from the World Development Indicators (WDI, 2021). All data except electric power consumption is available till 2018. Electric power consumption data is available till 2014 which is extrapolated for 4 years.

The time series data is generally non-stationary at the level which may produce spurious results if regressed at level. To avoid spurious regression the time series data are transformed to a higher order to induce stationarity. The long run relationship is lost in this transformation process if the appropriate statistical approach is not used. We apply the cointegration to achieve these seemingly contradictory objectives. We specify the following error correction model for estimation of dynamic relationship among the considered variables.

$$\Delta lnE_t = \psi_0 + \sum_{j=1}^{p} \psi \Delta lnF_{t-j} + \sum_{k=1}^{q} \psi \Delta lnI_{t-k} + \sum_{l=1}^{r} \psi \Delta lnA_{t-l} + \sum_{m=1}^{s} \psi \Delta lnY_{t-m} + \sum_{m=1}^{t} \psi \Delta lnE_{t-m} + \psi ECT_{t-1} + \varepsilon_t$$

As a standard procedure for time series analysis, we start with an investigation into the order of integration by applying Augmented Dickey-Fuller (ADF) and Philips-Parron (PP) tests of stationarity. ADF and PP stationarity tests are often criticized for their inability to handle the possible structural breaks in the series. In the presence of structural breaks, the conventional unit root tests such as ADF and PP may produce biased results towards rejection of the null hypothesis of no unit root (Perron 1989). In order to avoid this bias we apply Zivot and Andrews (1992) test of stationarity which considers the structural break in the series thus provides robust results in the presence of one unknown structural break. Zaviot and Andrews (1992) proposed the following three models to test the order of integration among the variables in the presence of one unknown structural break.

A. $y_t = \mu^a + \partial^a DU_t(\gamma) + \beta^a t + \delta^a y_{t-1} + \sum_{j-1}^{k} C_j^a \Delta y_{t-j} + \varepsilon_t$

B. $y_t = \mu^b + \beta^b t + \varnothing^b DT_t(\gamma) + \delta^a y_{t-1} + \sum_{j-1}^{k} C_j^b \Delta y_{t-j} + \varepsilon_t$

C. $y_t = \mu^c + \partial^c DU_t(\gamma) + \beta^c t + \varnothing^b DT_t(\gamma) + \delta^a y_{t-1} + \sum_{j-1}^{k} C_j^c \Delta y_{t-j} + \varepsilon_t$

Where DU_t in model-A represents the dummy intercept showing one structural break in the series, DU_t =1 in case (t >TB) and zero otherwise. DT_t in model-B represents the slope dummy; $DT_t = (t–TB)$ provided (t >TB) which shows a change in the slope, TB indicates the year of structural break.

After having information about the order of integration we proceed to lag length selection and testing the cointegration among the variables. Numerous approaches are used to tests the cointegration for studying the long run relationship such as Engle and Granger test (1987) Johansen and Juselius test (1990) Boswijik approach (1994) and Banerjee et al. (1998) test. The results of these conventional cointegration tests are often inconsistent which complicate the interpretation of the results. The choice of cointegration test is, therefore, always questioned as there is no any single criterion to select the most powerful test, even asymptotically (Elliott et al., 2005). Modified and robust approaches such as combined cointegration approach and ARDL bound testing approach may provide more accurate results to decide about the presence of long run relationship among series. Bayer and Hanck (2013) proposed a combined cointegration approach which overcomes the biases of conventional methodologies by combining the P-values of individual tests of cointegration by Fisher's (1932) Chi-squared test in the following manner.

$$x_T^{\sim 2} = -2\sum_{i\in T} \ln(P_i) \quad (2)$$

The long run relationship estimation schemes with Bayer and Hanck (2013) framework is presented below:

$$t_\gamma^{ADF} - \lambda_{max} = -2\left[\ln\left(P_{t_\gamma^{ADF}}\right) + \ln\left(P_{\lambda_{max}}\right)\right] \quad (3)$$

$$\lambda_{\max} - \hat{F} = -2\left[\ln\left(P_{\lambda_{\max}}\right) + \ln\left(P_{\hat{F}}\right)\right] \quad (4)$$

$$\hat{F} - t_\gamma^{ECR} = -2\left[\ln\left(P_{\hat{F}}\right) + \ln\left(P_{t_\gamma^{ECR}}\right)\right] \quad (5)$$

$$t_\gamma^{ADF} - \lambda_{max} - \hat{F} - t_\gamma^{ECR} = -2\left[\ln\left(P_{t_\gamma^{ADF}}\right) + \ln\left(P_{\lambda_{max}}\right) + \ln(P_{\hat{F}}) + \ln(P_{t_\gamma^{ECR}})\right] \quad (6)$$

Where t_γ^{ADF} stand for Engel-Granger, λ_{max} is for Johanson, $\hat{F}$ for Boswijk, λ_{max} for Banerjee et al. cointegration tests and $P_{t_\gamma^{ADF}}$, $P_{\lambda_{max}}$, $P_{\hat{F}}$ and $P_{t_\gamma^{ECR}}$ are the P-values of these cointegration tests respectively. The null hypothesis of no cointegration is rejected if the calculated value of the P-values through Fisher's formula is greater than the corresponding critical value tabulated by Bayer and Hanck (2013) or we accept the null hypothesis otherwise. We also applied ARDL bound testing approach to check the cointegration among model variables. ARDL bound testing in presence of structural breaks provides robust results by simultaneous inclusion of I(0) and I(1) variables in the model. ARDL bound testing approach also provides robust results even in small sample size and in presence of exogenous variables in the model. We specify the ARDL model as follows.

$$\Delta lnE_t = \alpha_0 + \alpha_T T + \alpha_F F_{t-1} + \alpha_I I_{t-1} + \alpha_A A_{t-1} + \alpha_Y Y_{t-1} + \alpha_E E_{t-1} + \sum_{j=1}^{p} \alpha \Delta lnF_{t-j} + \sum_{k=1}^{q} \alpha \Delta lnI_{t-k} + \sum_{l=1}^{r} \alpha \Delta lnA_{t-l} + \sum_{m=1}^{s} \alpha \Delta lnY_{t-m} \sum_{n=1}^{t} \alpha \Delta lnE_{t-m} + + \varepsilon_t$$

Where Δ is the first difference operator, T is the dummy for structural breaks in the series and ε_t is normally distributed error term. Following Shahbaz et al. (2015) we include the dummy variable in the model to allow the structural breaks in the series. We calculate ARDL F-statistics to check the cointegration among the model variables. We apply Wald test to confirm the cointegration with null hypothesis of no cointegration H_0: $\alpha_{EC}=\alpha_{FD}=\alpha_{ID}=\alpha_{AD}=\alpha_{ED}=\alpha_{CO2}=0$ against the alternative hypothesis H_1: $\alpha_{EC}\neq\alpha_{FD}\neq\alpha_{ID}\neq\alpha_{AD}\neq\alpha_{ED}\neq\alpha_{CO2}\neq 0$. Pesaran et al. (2001) tabulated asymptotic critical upper and lower bound values as decision criteria for hypothesis testing, which are mostly used for large sample size. Since we have sample size T-43 we preferred Narayan (2005)'s values as decision criteria due to its suitability for small sample size (T=30 to T-80). We compare the calculated F-statistics achieved through Wald test with the upper and lower bound critical values tabulated by Narayan (2005) for the decision on the no-cointegration hypothesis. We can reject the null hypothesis if the computed F-statistic value is greater than the upper bound critical value. We cannot reject the null hypothesis if the computed F-statistic is smaller than the lower bound critical value. The relationship is nondecisive if the computed F-statistic fall between the upper and lower critical bounds. We also perform various diagnostic tests for time series data to confirm the robustness of our cointegration results.

Once we get the evidence of cointegration we go for causality analysis. We apply Vector Error Correction Model (VECM) to estimate the short run and the long run dynamic causal relationship among the variables. We specify the VECM as follows:

$$(1-L)\begin{bmatrix} ln\,E_t \\ ln\,F_t \\ ln\,I_t \\ ln\,A_t \\ ln\,Y_t \end{bmatrix} = \begin{bmatrix} a_1 \\ a_2 \\ a_3 \\ a_4 \\ a_5 \end{bmatrix} + \sum_{i=1}^{p}(1-L)\begin{bmatrix} b_{11i} & b_{12i} & b_{13i} & b_{14i} & b_{15i} \\ b_{21i} & b_{22i} & b_{23i} & b_{24i} & b_{25i} \\ b_{31i} & b_{32i} & b_{33i} & b_{34i} & b_{35i} \\ b_{41i} & b_{42i} & b_{43i} & b_{44i} & b_{45i} \\ b_{51i} & b_{52i} & b_{53i} & b_{54i} & b_{55i} \end{bmatrix}$$

$$\times \begin{bmatrix} ln\,E_{t-1} \\ ln\,F_{t-1} \\ ln\,I_{t-1} \\ ln\,A_{t-1} \\ ln\,Y_{T-1} \end{bmatrix} + \begin{bmatrix} \gamma_1 \\ \gamma_2 \\ \gamma_3 \\ \gamma_4 \\ \gamma_5 \end{bmatrix} ECT_{t-1} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \\ \varepsilon_{4t} \\ \varepsilon_{5t} \end{bmatrix}$$

Where (1–L) is the lag operator, ECT_{t-1} is one period lagged error correction term, γ_1 to γ_6 are the adjustment coefficients and ε_{jt} (j=1, 2, 3, 4, 5) are normally distributed residual errors. Long run causal relationship is explained by statistical significance of negative lagged error correction terms. The short run causal relationship is determined by the combined statistical significance of parameter coefficients of lag period independent variables achieved through Wald test. We use Cumulative Sum (CUSUM) and Cumulative Sum of Squires (CUSUMsq) to check the stability of the ARDL parameters. We also check the robustness of the results of causal relationship with Innovative Accounting Approach.

4. EMPIRICAL RESULTS AND DISCUSSION

Descriptive statistics and correlation matrix have been presented in Table 1. The results show that average electric power consumption over the period of study is 287.04 kWh, which is far less than the world average of 2737 kWh. The domestic credit to the private sector remained 23.44% of the GDP, industrial value added 21.82% of the GDP, agricultural value added 24.98% of the GDP and real per capita GDP remained US constant $780.78 over the period of study. The contribution of the agriculture sector to GDP has decreased more than 10% of the GDP over the 47 years period from 36% in the year 1971 to 25% in the year 2018. The correlation coefficients show that industrialization and economic growth have highly significant and positive link with the electricity consumption. Financial development has a positive but weak correlation with electricity consumption. However, agricultural development has a negative and significant correlation with the electricity consumption. The significant correlation among the independent variables causes spurious regression if regressed at their level. The transformation of variables to different order and use of cointegration approach can effectively handle this problem.

Table 1: Descriptive statistics and correlation matrix

At level	*E*	*F*	*I*	*A*	*Y*
Mean	287.04	23.44	21.82	24.98	780.78
Std. Dev.	134.3779	3.2381	2.7040	3.9000	145.1440
Jarque-Bera	3.8318	0.7036	1.6897	4.1548	2.3966
Probability	0.147213	0.7034	0.4296	0.1253	0.3017
Log Level	***lnE***	***lnF***	***lnI***	***lnA***	***lnY***
Mean	5.5355	3.1604	3.0753	3.3037	6.2797
Std. Dev.	0.5561	0.1421	0.1242	0.1371	0.2744
Jarque-Bera	3.9753	1.1131	1.7067	2.4480	2.8553
Probability	0.1370	0.5562	0.4260	0.2940	0.2399
Correlations at Level					
lnF	0.0420				
lnI	0.9557	−0.0019			
lnA	−0.9159	−0.1391	−0.9058		
lnY	0.9775	−0.0137	0.9839	−0.9214	

As the first step in cointegration analysis, we perform the unit root test on the considered variables to check the time-series properties of the variables. Table 2 presents the results of standard tests of unit root such as ADF and PP, first by including only constant and then both constant and trend in the equation. The results provide evidence in support of stationarity of series electricity consumption, financial development, industrialization, agricultural development and economic growth when first differenced but not at their level. The ADF and PP unit root tests results suggest that all the series are integrated at their first difference level I(1) but not at their level I(0). The results of the unit root tests that do not consider the structural breaks in the series may lead to biased judgment about the order of integration if there are structural breaks in the series. In order to avoid this biase in the decision about the order of integration, we also apply Zaviot and Andrews (1992) unit root test. This test by considering the one unknown potential endogenous structural breaks in the series provides better results about the order of integration for the unbiased conclusion.

The results of Zavior and Andrews unit root test are presented in Table 3. Overall the results are consistent irrespective which unit root test is applied. The structural break unit root test results show that all the series under the consideration are stationary at the first difference level in the presence of structural breaks but non-stationary at their level. The test results identified the time break in the series electricity consumption, financial development, and agricultural development in the year 2004, which correspond to the year of financial liberalization, prudent economic reforms, and all macroeconomic indicators exhibited a great improvement in Pakistan. During this year credit rating agencies including Moody's and Standard & Poor upgraded the credit rating of Pakistan due to sound economic growth and prudent financial policies.

After having information about the order of integration among the model variables we proceed to test the presence of a long run relationship. Since all of our model variables are I(1) integrated, we can use the combined cointegration approach developed by Bayer and Hanck (2013) to check the presence of cointegration among the model variables. The results of the Bayer and Hanck's combined cointegration approach are exhibited in Table 4. The results provide evidence in support of presence of long run relationship among the model variables. The calculated combined P-values, through Fisher's formula for all combinations of cointegration

Table 2: Augmented Dicky Fuller and Philips Parron test results

Variables	ADF Test				P-P Test			
	Level		First Difference		Level		First Difference	
	C	*C&T*	*C*	*C&T*	*C*	*C&T*	*C*	*C&T*
P_t	−1.5632	−0.3285	−5.4487*	−5.7875*	−1.5632	−0.3285	−5.4526*	−5.7851*
F_t	−2.7495	−2.3937	−5.1707*	−5.1257*	−1.6377	−1.2234	−5.2117*	−5.1709*
I_t	−0.7494	−2.8518	−3.3349**	−3.2582**	−1.0628	−3.4324	−8.1332*	−8.1378*
A_t	−1.9224	−1.6393	−6.1539*	−6.4701*	−1.9418	−1.6393	−6.1545*	−6.5267*
Y_t	−1.6416	−1.4880	−5.6259*	−5.8409*	−0.9433	−1.4492	−5.6688*	−5.8429*

*And ** show significant at 1% and 5% levels respectively

Table 3: Zivor and Andrews test results

Variables	Level			First difference		
	Time Break			Time Break		
$\ln E_t$	−2.8205	(0)	2004	−6.2355*	(1)	1987
$\ln F_t$	−3.4606	(0)	2004	−5.2355*	(0)	2003
$\ln I_t$	−3.9850	(0)	1995	−10.0169*	(1)	2004
$\ln A_t$	−3.1665	(0)	2004	−7.2415*	(1)	2000
$\ln Y_t$	−4.2474	(2)	1997	−6.7317*	(0)	2004

*And ** show significant at 1% and 5% levels respectively

tests, are consistently greater than the tabulated values at 1% level in case of electricity consumption and financial development models. However, in the case of economic growth model the calculated combined P-values is lower than 1% but greater than 10% which indicates the rejection of the null hypothesis of no-cointegration at 10% level. The calculated combined P-values in industrialization and agriculture development models are lower than the critical values of the tests thus lead to non-rejection of the null hypothesis. The results provide evidence in support of at least three cointegration vectors in our model.

The ARDL bound testing approach was also used to confirm the existence of cointegration among the model variables as a robustness check. Following Shehbzaz and Lean (2012), Shahbaz et al. (2013) and Alkhathlan and Javid (2015), we also included a dummy variable for the structural breaks in the ARDL equation to capture the effect of time break in series. The results of ARDL bound testing are exhibited in Table 5. The results are consistent with the Bayer and Hanck approach and confirm the presence of cointegration among the variables at I(1) level in case of electricity consumption and financial development models at 1% significance level. In the case of economic growth, the test results support to reject the null hypothesis at 5% significance for I(1) integration. Nonetheless, in the case of industrialization and agricultural development, the results do not support rejection of the null hypothesis. The ARDL bound testing approach leads to the decision in favor of long-run relationship among the model variables and presence of three cointegration vectors at I(1) level.

After having information about the order of integration and existence of long run relationship among the model variables, we proceed to estimate the short run and long run dynamic relationship among the variables through UECM. The results are interpreted in terms of elasticities as our model holds the logarithmic specifications. The long run and short run estimates of elasticities are exhibited in Table 6. The results show that financial development has positive and statistically significant impact on the electric power consumption both in the short run and long run. A 1% increase in the domestic credit growth requires 0.29% increase in the electric power consumption in the long run and 0.42% in the short run, at 1% significance levels. It indicates that the electric power consumption is more elastic to financial development in the short run compared to the long run. Industrial growth is another significant determinant of long run electric power consumption in Pakistan. A 1% increase in industrial growth results in 0.50% increase in electric power consumption in the long run at 1% significance level. However, the short-run positive link is not statistically significant, this result was anticipated as the electric power supply is not driven by industrial sector consumption rather some other supply side factors.

Another interesting result that we found is the negative link between agriculture and electric power consumption. The results show that a 1% decrease in the contribution of agricultural value added in GDP results in 0.23% increase in electric power consumption in the short run and 0.29% in the long run, the relationship is statistically significant at l% and 10% levels respectively. There are three possible reasons of this unusual result. First, the rapid transformation of agricultural land into housing colonies and industrial states cause the decrease in agricultural output and increase in energy demand. Second, the migrations to cities in search of a better life as most of the villages in Pakistan lack basic necessities such as education, healthcare, clean drinking water, and electricity. Third, the government prioritizes the cities for electric supply over the rural areas. The electricity outage sometimes reaches to 18 h per day in villages, resulting in low agriculture output. The economic growth has a positive impact on energy consumption both in the short run and long run. However, in the long run the electric power consumption is less elastic to economic growth as a 1% increase in economic growth results in 0.55% increase in electric power consumption and the relationship is statistically significant at 1% level. In short run, 1% increase in economic growth results in 0.92% increase in electric power consumption at 10% significance level.

The negative and statistically significant value of one period lagged error correction term indicates that any disequilibrium due to random shocks is corrected 15.26% per year. Figure 1 depicts the plot of CUSM and CUSM of square show that our electricity consumption model is stable. Other diagnostic tests also favor the robustness of the estimated models.

The presence of cointegration among the variables under the consideration indicates the existence of at least one-way causality

Table 4: Bayer and Hanck combined cointegration test results

Estimated models	$t_{\gamma}^{ADF}-\lambda_{max}$	$\lambda_{max}-\hat{F}$	$\hat{F}-t_{\gamma}^{ECR}$	$t_{\gamma}^{ADF}-\lambda_{max}-\hat{F}-t_{\gamma}^{ECR}$	Decision
$EP_t = f(FD_t, ID_t, AD_t, ED_t, CO2_t)$	17.3947	15.8735	18.2361	32.5267	Yes*
$FD_t = f(EP_t, ID_t, AD_t, ED_t, CO2_t)$	18.2385	16.3845	16.3456	31.6744	Yes*
$ID_t = f(FD_t, EP_t, AD_t, ED_t, CO2_t)$	5.6743	6.2945	6.6135	14.7840	No
$AD_t = f(FD_t, ID_t, EP_t, ED_t, CO2_t)$	9.6241	8.4563	7.2345	12.4987	No
$ED_t = f(FD_t, ID_t, AD_t, EP_t, CO2_t)$	11.6352	10.9475	8.524	23.5928	Yes***
Critical Values at 1%	15.701	15.143	17.813	29.850	
Critical Values at 10%	8.242	8.105	8.339	15.804	

*And *** show significant at 1% and 10% levels respectively

Table 5: ARDL bound testing results

Variables	lnP_t	lnF_t	lnI_t	lnA_t	lnY_t
F-Statistics	5.2210*	4.9628*	1.4423	2.5534**	5.4595*
P-values of Wald	0.0015	0.0024	0.2480	0.0497	0.0009
Structural break	(1987)	(2003)	(2004)	(2000)	(2004)
Decision	Yes**	Yes**	N0	N0	Yes**
critical value	1%	5%	10%		
Narayan					
upper bound	5.898	4.338	3.708		
lower bound	4.045	2.962	2.483		

*And ** show significant at 1% and 5% levels respectively

Table 6: Short term and long run and long run elasticity estimates

Dependent Variable E			
Variables	**Coefficient**	**Std. error**	**T-statistics**
Long-run results			
Constant	*−1.8521**	*0.3766*	*−4.9174*
lnF	0.2897*	0.0855	3.3883
lnI	0.5058*	0.1126	4.4920
lnA	−0.2258*	0.0794	−2.8438
lnY	0.5497*	0.1495	3.6780
Short run results			
$\Delta lnFD$	0.4212*	0.1188	3.5454
$\Delta lnID$	0.1239	0.3110	0.3982
$\Delta lnAD$	−0.2912***	0.1465	−1.9876
$\Delta lnED$	0.9391**	0.4611	2.0337
ECM_{t-1}	−0.1526*	0.0550	−3.7731
R^2	0.6372		
Adj-R2	0.5980		
F-Statistics	41.7629	(0.0000)	
Diagnostic tests			
	F-statistics	**P-value**	
$\chi^{2normal}$	1.7454	0.4175	
$\chi^{2serial}$	2.2185	0.3041	
χ^{2white}	0.9837	0.6742	
$\chi^{2Remsay}$	2.3265	0.2976	

*, **And *** show significant at 1%, 5% and 10% significance levels respectively

between variables. The UECM does not suggest the direction of causality. Therefore, we applied VECM based Granger causality test to investigate the direction of causality between the considered variables. The direction of combined joint short run and long run causality is achieved through Wald test. The Chi-square values and corresponding P-values of the granger causality test are exhibited in Table 7. We found a reciprocal causality between electricity consumption and economic growth, thus, favoring the feedback hypothesis in the case of Pakistan. Raza et al. (2015) have also reported the reciprocal causal relation between aggregate energy consumption and economic growth. The results imply that electricity conservation policies may impede the economic growth in Pakistan. There is also a bi-directional causality between economic growth and financial development. Electricity consumption and financial development Granger cause each other. A unidirectional causality is running from industrialization to electricity consumption and financial development. Agricultural development and industrialization granger cause the economic growth.

Further investigation into the disaggregate short run and long causality may provide better insights to assist the policy makers in the formulation of effective policies to curb the energy crisis in Pakistan. The results of disaggregate causal relationship are reported in Table 8. The results show that one-period lag error correction term is negative and statistically significant in EP and FD equations, which indicates a bidirectional long run causality between the electricity consumption and financial development. The ECT_{t-1} in the case of agricultural development and economic growth equations is positive which indicate the absence of long-run joint causality running from the set of independent variables to dependent variable. In industrialization equation, the ECT_{t-1} is negative but statistically insignificant, which does not support the long run causality hypothesis running from the set of independent variables to industrial growth in the equation. The results suggest a long-run unidirectional causality running from the industrialization, agricultural development, and economic growth to electricity consumption and financial development. This finding supports the conservation hypothesis in the case of electric power as energy sources in Pakistan in the long run. Jamil and Ahmed (2010) also reported the empirical results favoring the conservation hypothesis by sectoral analysis of electricity consumption in relation to electricity prices and GDP. It is worth noting that Raza et al. (2015) reported a bidirectional causality between total energy consumption and economic growth in case of Pakistan over the same period. The difference in the results of electric power consumption and total energy consumption suggests that long-term electric power conservation policies may not impede the economic growth of Pakistan. The difference in the direction of causality running from electricity consumption to economic growth and total energy consumption to economic growth as reported by Raza et al. (2015) may be attributed to the dependence of electricity consumers on alternate energy sources because of scheduled and nonscheduled power cuts.

The short run causal relation among the model variables is tested through Wald test for the combined significance of lagged period

Table 7: Joint short and long run causality effects ϰ2 statistics

Variables	$E\&ECT_{t-1}$	$F\&ETC_{t-1}$	$I\&ETC_{t-1}$	$A\&ETC_{t-1}$	$Y\&ETC_{t-1}$
ΔE		17.2039* (0.0006)	7.9710** (0.0466)	7.5149 (0.0572)	9.3005** (0.0256)
ΔF	7.9252** (0.0476)		16.9982** (0.0007)	7.6278 (0.0544)	10.1044** (0.0177)
ΔI	5.8321 (0.1201)	5.2416 (0.1549)		5.0224 (0.1702)	4.9700 (0.1740)
ΔA	8.9470** (0.0300)	1.4667 (0.6900)	2.1497 (0.5419)		2.7748 (0.4277)
ΔY	9.5821** (0.0225)	9.7400** (0.0209)	10.1759** (0.0171)	8.3236** (0.0398)	

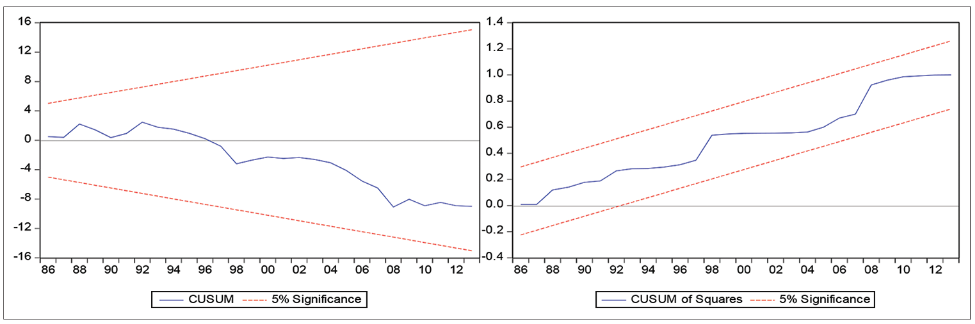
*, ** And *** indicate significance at 1% and 5% levels. P-values within parenthesis

Table 8: Granger causality/Block Exogeneity tests within framework of VECM results

Variables	E $\varkappa^2$	F $\varkappa^2$	I $\varkappa^2$	A $\varkappa^2$	Y $\varkappa^2$	ECT_{t-1}
ΔE		7.0502* (0.0240)	6.9648** (0.0307)	0.7978 (0.6711)	1.9202 (0.3829)	−0.1470** (0.0294)
ΔF	2.4478 (0.2941)		1.1470 (0.5636)	2.6505 (0.2657)	2.3279 (0.3123)	−0.1460** (0.0146)
ΔI	3.8350 (0.1470)	0.5086 (0.7754)		5.0192*** (0.0813)	0.3217 (0.8514)	−0.5526 (0.1104)
ΔA	8.8620** (0.0119)	0.4556 (0.7963)	2.1496 (0.3414)		2.6890 (0.2607)	0.2181 (0.4161)
ΔY	3.9106 (0.1415)	0.5070 (0.7761)	10.1202* (0.0063)	2.0172 (0.3647)		0.2191 (0.1460)

*, ** And *** indicate significance at 1%, 5% and 10% levels. *P* values within parenthesis

Figure 1: Cumulative sum and cumulative sum of squares of recursive residuals



variable parameter coefficients. The results show that short-run causality is running from the financial development and industrial growth to electricity consumption. Electricity consumption granger causes the agricultural development. We also note that the short run causality is running from the agricultural growth to industrialization and from industrialization to economic growth. This finding suggests that a balanced economic growth cannot be achieved without a sound agriculture sector in Pakistan. The development of agriculture sector may also greatly contribute to curbing the energy crises and environmental degradation.

5. CONCLUSION AND POLICY IMPLICATIONS

This paper aims to investigate the interactive role of financial development, industrialization, agricultural growth and economic growth in electricity consumption in Pakistan over the period 1971 to 2018. We used structural break unit root test in addition to standard tests of stationarity to confirm the time series properties of the model variables. The presence of cointegration among the variables was tested with the combined cointegration technique newly developed by Bayer and Hanck (2013) as well as ARDL bound testing approach in the presence of structural breaks. The short run and long run elasticities were estimated by linear transformation of ARDL model to UECM. The direction of causality among the variables was checked through Granger causality test within the framework of VECM.

The empirical results support the presence of long run relationship among the model variables at I(1) level of integration. The presence of cointegration among the model variables indicates the existence of long-run equilibrium path. The elasticity estimates show that financial development and economic growth induce electricity consumption in the long run as well as in the short run. We note that in the long run a 1% increase in the contribution of the industrial sector to GDP requires 0.51% increase in electricity consumption, contrary to that a 1% increase in the contribution of agriculture sector to GDP results in 0.23% decrease in electricity consumption. Meanwhile, the agricultural growth granger causes the industrial growth. This finding suggests a unique opportunity for Pakistan to sustain the economic growth despite the crippling energy crisis by developing and promoting the agriculture sector. The agriculture-based economic growth would greatly help in mitigating the negative impact of the energy crisis and also contribute in achieving sustainable green growth.

Although the unrestricted error correction model indicates the presence at least one-way causal relation among the model variables, it does not suggest the direction of causality. The direction of causality among the model variables has great policy implications. We achieved the direction of causality through Granger causality within the framework of VECM. The joint short run and long run Chi-square statistics favor the feedback hypothesis in the case of Pakistan. The combined short run and long run causal relation have limited policy implications, therefore, the disaggregate analysis may provide better insights.

Further investigation into causal relationship reveals that there is a unidirectional causality running from economic growth to electricity consumption in the long run which supports the conservation hypothesis. However, there is no sign of short run causal relation which favors the neutrality hypothesis.

The results show that short run unidirectional causality is running from the electricity consumption to agricultural growth. If we interpret the one-way causality along with negative parameter coefficient of agriculture growth in electricity consumption equation, it is clear that the short supply of electricity is responsible for the dwindling contribution of agriculture sector in the GDP. The decrease in agriculture output also adversely affect the industrial sector as suggested by the short-run causality running from agriculture growth to industrialization. A significantly large part of Pakistan' industrial sector consists of agriculture-based industries such as Textile, Sugar, Chemical and Engineering.

The findings have significant policy implications for Pakistan. The empirical results confirm the industry driven financial development. This finding suggests that short-term conservative financial policy may be implemented to decrease the energy consumption without compromising the economic growth. Prudent rationing of available electric power among the agricultural, industrial and household sector may also help in minimizing the adverse effects of the energy crisis.

Being an agricultural economy, Pakistan has great potential for agriculture-led green growth. More specifically, the policy makers should make a composite policy to promote and develop the agriculture sector of Pakistan. The inefficiencies in agriculture sector may be eradicated by promoting the culture of corporate farming, liberal credit policy for agriculture sector and technical assistance to use modern agricultural technologies. Provision of technical and financial assistant to the farmers to encourage the use of biofuel and renewable energy sources may greatly help in combating the energy crisis.

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