Financial Development, Economic Growth, and Electricity Demand: A Sector Analysis of an Emerging Economy

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Abstract

We employ an augmented production function to examine the association between electricity consumption and economic growth at the aggregate and sectoral levels for the period 1972-2014 for Pakistan. We posit that financial development is an important driver of electricity consumption and economic growth. The unit root test, combined cointegration framework, and VECM Granger causality approach are applied.

There is a long-term association between the variables at the aggregate and sectoral levels. Electricity consumption and financial development stimulate economic growth. The causality analysis validates the presence of the feedback effect between economic growth and electricity consumption. Bidirectional causality exists between financial development and electricity consumption in the agriculture and services sectors. Financial development drives electricity consumption in the industrial sector. Policies have to be implemented to maintain sufficient electricity supply for economic growth. The financial sector should incentivize investment in renewable energy to reduce Pakistan's heavy reliance on oil imports.

Keywords: Financial development, Electricity consumption, Economic growth, Energy policy, Bidirectional causality, Feedback effect, Electricity demand–supply gap, Non-renewable energy, Carbon Emissions, Pakistan

JEL Classifications: O41, O47

1. Introduction

The debate on the electricity-growth or energy-growth nexus has received significant attention from researchers in the energy literature initiated by Kraft and Kraft[1]. The empirical findings have not helped policy makers in designing a comprehensive energy policy for sustainable economic development owing to the controversial nature of estimated growth models, energy demand functions, and/or omissions of relevant variables[2-6]. For instance, ecological economists argue that energy sources play a vital role in the production function because energy consumption derives economic growth[7-9]. Additionally, energy consumption contributes to living standards in developed and developing economies[10]. The neoclassical school of thought prescribes that energy demand causes economic growth[11]. Additionally, Lermit and Jollands[12] document that energy demand derives from economic growth.

Previous work highlights that the omission of important factors affecting the energy-growth nexus causes spurious findings. For example, important factors include capital and labor[5], technological advancement[13], employment[14,15], energy prices[16,17], real investment as well as net investment[18,19], carbon emissions[20], and consumer prices[21]. These factors were incorporated into the production function while investigating the relationship between electricity consumption and economic growth. The debate, however, is ongoing, and findings on this subject are inconclusive[22-23].

The existing literature mostly ignores the role of financial development in stimulating economic growth and the effect of economic growth on energy demand. Karanfil[24] documents the importance of financial variables to investigate the energy-growth nexus. Sadorsky[25,26] empirically examines the relationship between financial development and energy consumption and reports that financial development is an established and effective tool in boosting economic growth as well as energy consumption. Financial development reflects the actual level of financial resources available for production purposes and channels these funds via banks and stock markets[27]. Financial development contributes to economic growth by boosting investment via transparent transactions for productive ventures. Developed financial markets attract domestic and foreign direct investment (FDI)[25]. A higher level of financial development allows banks to pool resources for investment projects[25,27,28].

Three mechanisms link financial markets to economic growth and, thus, energy consumption. (i) The *level effect* shows how developed financial markets channelize resources to high return projects. Financial development also implies better accounting and reporting standards, which increase investor confidence[29] and attract FDI[25,30]. This investment affects energy consumption. (ii) The *efficiency effect* implies that financial development improves liquidity and allows asset allocation to appropriate ventures that add to energy consumption. (iii) The financial sector provides cheaper consumer loans encouraging consumer purchases, particularly of durable items such as automobiles, homes, refrigerators, and air conditioners[25], which contribute to energy use (the so-called *consumer effect*).

Existing studies on energy (electricity) growth provide inconclusive empirical findings[31]. Jobert and Karanfil[32] argue that the dynamic relationship between electricity consumption and economic growth at an aggregate level does not provide a sufficient basis for policy makers to design a comprehensive energy (electricity) policy for sustainable economic development. Abid and Mraihi[33] argue that the relationship between sectoral electricity consumption and sectoral economic growth aids policy makers in designing micro-level energy and growth policies.[i] Finally, the presence of structural breaks in energy (electricity) variables resulting from a change in policies or regime shifts may render traditional unit root tests inappropriate.

Traditional cointegration tests between electricity and other economic variables that exclude these structural breaks result in spurious findings[ii,34] and may affect the forecasting performance of econometric models[35]. Overlooking structural breaks in energy or non-energy variables may be the cause of unreliable empirical results[36]. Shahbaz et al.[37] suggest considering the structural break unit root test(s), cointegration, and causality approaches to obtain consistent and reliable empirical evidence on the electricity-growth nexus. Existing studies in the energy literature ignore the role of structural breaks in long-run and short-run relationships between the energy and non-energy variables.

This present study contributes to the existing energy literature by presenting a comprehensive analysis for Pakistan by covering all the above-mentioned factors.

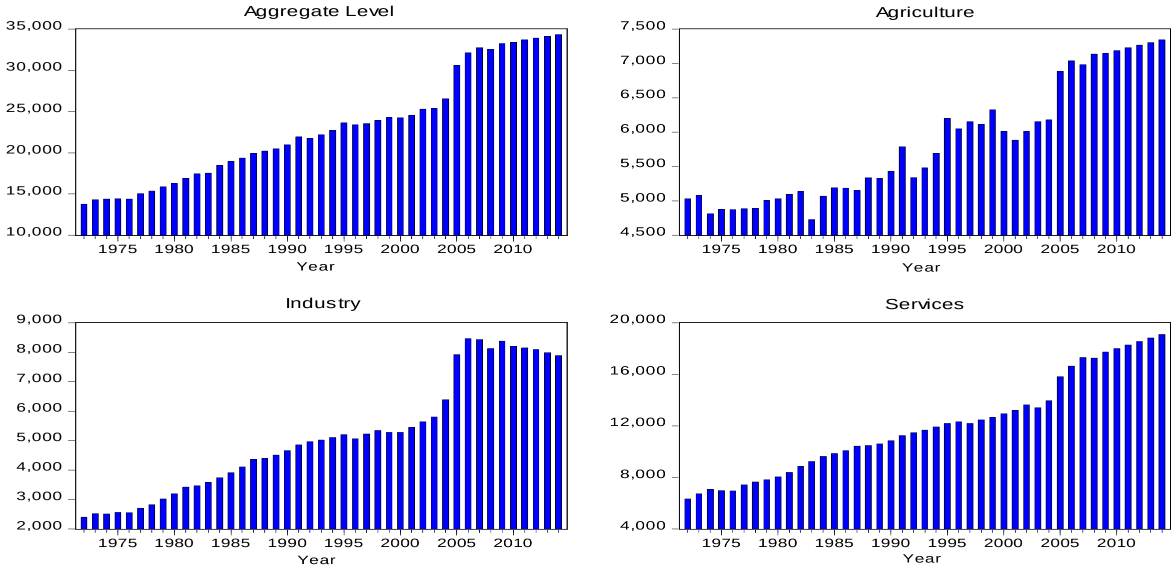
(i) This study employs an augmented production function by incorporating the role of capital and labor at sectoral levels. (ii) The augmented production function at sectoral levels includes financial development. (iii) The unit root test accommodating structural breaks is applied to identify potential break periods. (iv) The combined cointegration approach developed by Bayer and Hanck[38] and the structural break cointegration approach are used to test the presence of cointegration and the robustness of the results. (v) This study incorporates a break dummy for both the long and the short runs to capture the impact of structural breaks in economic growth at the aggregate and sectoral levels. (vi) The VECM Granger causality approach is applied to determine the direction of causality between electricity consumption and economic growth at the aggregate and sectoral levels.

Our empirical findings confirm the presence of cointegration between the variables at the sectoral and aggregate levels. Electricity consumption adds to economic growth, while financial development positively affects economic growth. Capital is negatively linked with economic growth, and labor is a major contributor to it. The causality analysis indicates the presence of the feedback effect between electricity consumption and economic growth. Moreover, financial development and electricity consumption are complementary. The feedback effect between electricity consumption and economic growth is present at the aggregate and sectoral levels, and a similar outcome is found for financial development and electricity consumption.

1.1 Electricity Consumption and Real GDP Trends at the Sectoral Level for Pakistan

Agriculture, industry, and services are sectors [iii] contributing to Pakistan's economic growth.[iv] Figure-1 shows that the share of the services sector has improved, and a decline is noted in the agriculture sector owing to a hike in electricity and diesel prices. Similarly, the industrial sector's contribution to the GDP shows a decline after the year 2007 owing to a severe electricity shortage. The industrial sector consumes a higher share of total electricity than agriculture but produces an almost equivalent share of the GDP as agriculture. The services sector's contribution to the GDP is consistently growing. From 2013-2014, electricity consumption by the agriculture sector amounted to 10% of total electricity consumption.

Figure-1: Trends in Real GDP per Capita for Pakistan



Similarly, the industrial sector consumed 29% of total electricity for this period (see Figure-2). The services sector's electricity consumption reached 61% of total electricity consumption in 2013-2014. At the aggregate level, income per capita has been rising consistently, but overall electricity consumption shows a decline after 2010 possibly owing to a growing electricity demand-supply gap.

Figure-2: Trends in Electricity Consumption per Capita for Pakistan

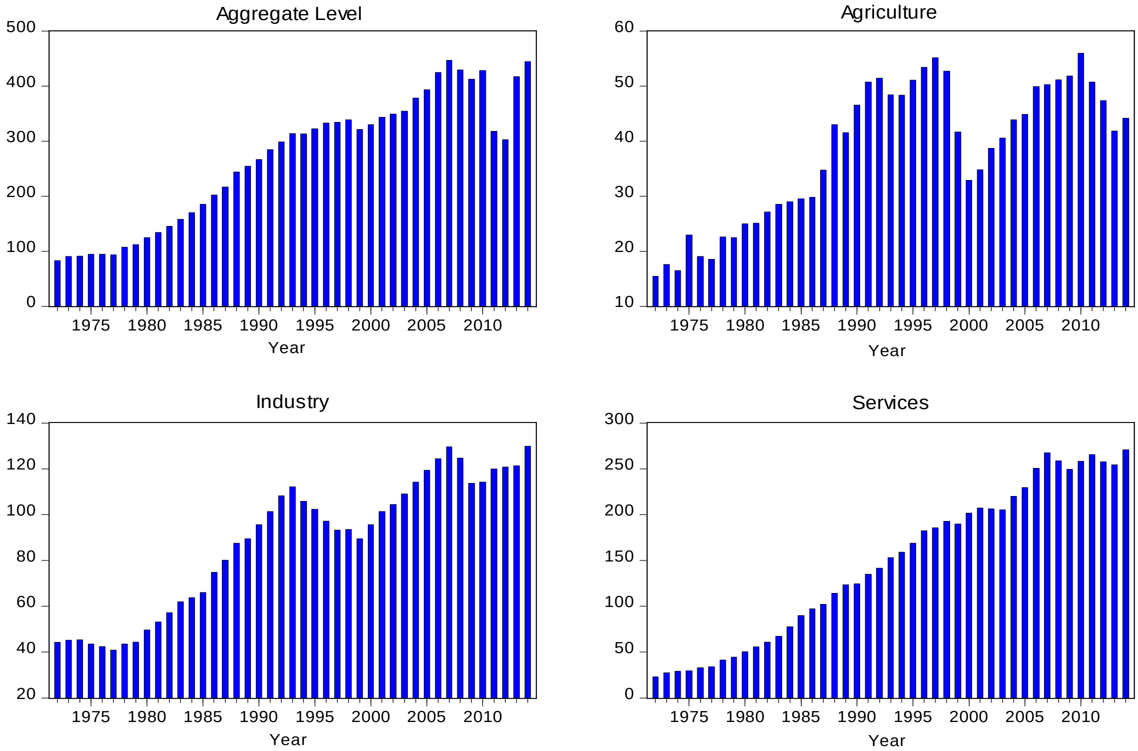


Figure-3: Trends in Domestic Credit per Capita for Pakistan

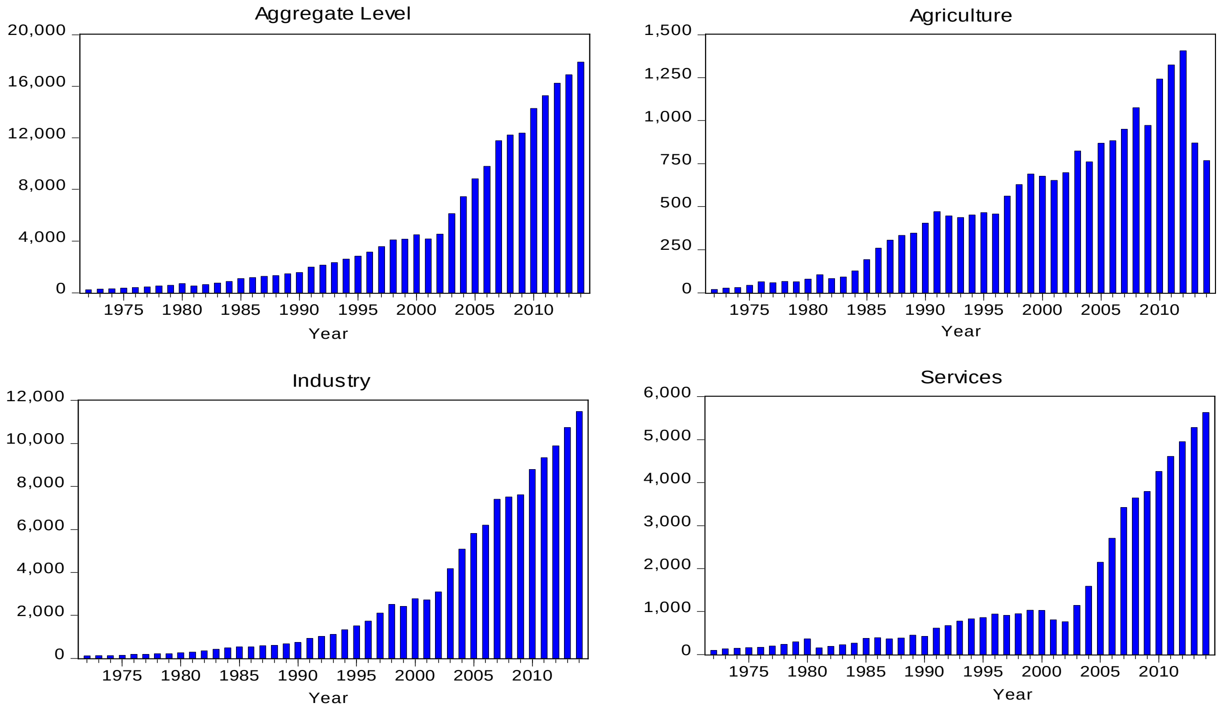


Figure-3 shows the demand for loans in the agriculture sector declined after 2013, because of severe floods that reduced agricultural productivity. The provision of domestic credit to the industry and services sectors increased during the sampled period of 1972-2014, which motivates us to examine the dynamic relationship between electricity consumption, financial development, and economic growth. In doing so, we intend to provide guidelines for sustainable economic development to policy makers and practitioners.

The rest of this paper is organized as follows. Section-II describes the relevant literature. Section-III presents the empirical model and data collection, while the methodological framework is discussed in Section-IV. Section-V discusses the empirical results. Section-VI concludes with policy implications.

2. Literature Review

We divide the existing literature into two categories: (i) electricity consumption and economic growth nexus, and (ii) financial development and energy consumption nexus.

2.1 Economic Growth and Electricity Consumption

The literature on sectoral energy consumption and economic growth is limited. For example, Jobert and Karanfil[32] examine this relationship in the Turkish economy. They find that both variables are cointegrated, and a neutral effect exists between economic growth and energy demand at the aggregate and sectoral levels. However, the contemporaneous values of energy consumption and incomes are correlated. For the Iranian economy, Zamani[39] examines the association between energy consumption and economic growth at the sectoral level. He shows that industrial output growth causes electricity consumption, and a feedback effect exists between agricultural growth and total energy consumption. Soytas and Sari[40] apply a production function to investigate the link between energy consumption and industrial output growth for the Turkish economy. They find cointegration between the variables, and industrial output growth causes electricity consumption. Ewing et al.[41] investigate the link between industrial production and energy consumption (at the disaggregate level) by applying a bounds testing approach to cointegration. Their findings show the neutral effect between electricity consumption and economic growth, but renewable energy sources stimulate economic activity. Sari et al.[42] reexamine the linkage between disaggregate energy consumption and industrial output in the US.[v] For the Chinese economy, Yuan et al.[43] examine the relationship between disaggregate energy consumption and economic growth using the VECM Granger causality and impulse response functions. The authors' results show that economic growth causes electricity and oil consumption, but the opposite is not true. Hu and Lin[44] examine the association between disaggregate energy consumption and economic growth by applying threshold cointegration for the Taiwan economy. Their findings agree with Lee and Chang[34,45]. Similarly, Cheng-Lang et al.[46] reinvestigate the relationship between sectoral (industrial and residential) electricity consumption with economic growth.[vi] For South Africa, Ziramba[47] scrutinizes the alliance between disaggregate energy consumption and industrial growth, and reports a feedback effect.

Bowden and Payne[48] examine the association between energy consumption and sectoral economic growth by applying the Yamamoto–Toda Granger causality approach for the US. Pao and Fu[49] examine the association between energy sources and economic growth using Brazilian data.[vii] Chiazoka et al.[50] scrutinize the association between electricity supply and industrial output for the Nigerian economy and report that electricity supply plays a vital role in spurring industrial growth. Lean and Smyth[51] use disaggregate fuel types and real GDP to examine the relationship between energy consumption and economic growth in Malaysia. Their results indicate that Malaysian economic growth causes diesel, fuel, oil, kerosene, and petroleum consumption. Ohler and Fetters[52] use data on disaggregate electricity generation sources and economic growth in OECD countries. They find that biomass, hydroelectricity, waste, and wind promote economic activity and, hence, economic growth. Moreover, their empirical findings indicate the existence of the feedback effect between renewable electricity generation and economic growth. For the Tunisian economy, Abid and Mraihi[33] examine the relationship between the energy-growth nexus using disaggregate data for energy consumption and industrial production.[viii] Hajko[53] empirically reports the unidirectional causal relationship running from energy (electricity) consumption to industrial output growth. For the Malaysian economy, Rahman et al.[54] examine the relationship between energy consumption and sectoral production using aggregate and disaggregate data. They find unidirectional causality running from energy consumption to economic growth (manufacturing), and report the feedback effect.

For Pakistan, Mahmud and Chishti[55] explore the linkages between energy and manufacturing output utilizing the Divisa index. Aqeel and Butt[56] apply the Hsiao Granger causality to examine the association between disaggregate energy consumption and economic growth. Their results show that both energy (petroleum) and electricity consumption cause economic growth. Jamil and Ahmad[57] employ the trivariate model to examine the relationship between electricity consumption, economic growth, and electricity prices. They find that economic growth is positively linked with electricity consumption at the aggregate and disaggregate levels, and electricity demand increases private expenditures in the residential sector. Jamil and Ahmad[58] reinvestigate the major contributing factors of electricity demand function and find that economic growth has a positive impact on electricity consumption at both the aggregate and disaggregate levels. They note that energy and non-energy (capital and labor) variables play a vital role in stimulating manufacturing output.

Shahbaz et al.[28] reexamine the relationship between energy (renewable energy and non-renewable energy) consumption and economic growth, and find bidirectional causality between energy sources and economic growth. Qazi and Yulin[59] analyze the link between industrial output and electricity consumption, and report a unidirectional causality running from electricity consumption to industrial growth. Using sectoral level data, Tang and Shahbaz[60] examine the relationship between electricity consumption and economic growth. They apply the TYDL Granger causality approach for the analysis and report that growth in the manufacturing and service sectors is a Granger cause of electricity consumption. Abbas and Choudhary[61] examine the linkage between electricity consumption and economic growth using aggregate and disaggregate data. Their empirical evidence reveals bidirectional causality between electricity consumption and economic growth at the aggregate level, and economic growth causes electricity consumption in the agriculture sector. Mirza et al.[62] study the relationship between electricity consumption and sectoral output (industrial and services sectors) and note that electricity consumption boosts sectoral output. The VECM Granger causality analysis suggests the existence of a feedback effect between electricity consumption and industrial output, and unidirectional causality exists, running from electricity consumption to the services sector's output. Table-1 reports the summaries of previous work on this subject.

Table-1: Selected Studies on Energy-Growth Nexus

No.	Study	Country	Variables	Techniques	Findings
1	Aqeel and Butt[56]	Pakistan	Y, TE, PC, G, EC, E	GC, HC	$PC \rightarrow Y$, $EC \rightarrow Y$, $TE \rightarrow E$
2	Mustaq et al.[62] (2007)	Pakistan	Y, G, EC, TO, OP, EP, GP	J–J, GC	$EC, O \leftarrow Y$
3	Jobert and Karanfil[32]	Turkey	Y, IND, PC, EC, G, CC, TC	GC	$TC \rightarrow Y$
4	Ewing et al.[41]	US	IND, G, CC	VDA	G and CC lead IND
5	Soytas and Sari[40]	Turkey	EC, M, E, I	ARDL, VECM	$EC \rightarrow M$
6	Zamani[21]	Iran	IND, A, G, EC, TE, PC	VECM	$TC \leftrightarrow M$, $TC \leftrightarrow A$
7	Sari et al.[42]	USA	REC, NRC, E, IND	ARDL	Mixed results
8	Yuan et al.[43]	China	EC, Y, K, E	J–J, VECM	$EC, O \rightarrow Y$
9	Hu and Lin[44]	Taiwan	Y, TC, CC, G, EC	Non-linear VECM	EC leads Y
10	Ziramba[47]	South Africa	IND, CC, EC, O	ARDL, T–Y	$O \leftrightarrow Y$
11	Bowden and Payne[48]	USA	REC, NRC, Y	T–Y	$REC, NRC \rightarrow Y$
12	Jamil and Ahmad[57]	Pakistan	A, IND, SE, Y, EC	J–J, VECM	$EC \leftarrow Y, A, IND, SE$
13	Liew et al.[63]	Pakistan	TE, IND, A, SE	J–J, GC	$TE \leftrightarrow A$, $IND, SE \rightarrow TC$
14	Faisal and Nirmalya [64]	Pakistan, India	EC, Y, A, AEC	J–J, VECM	$EC \leftrightarrow Y, AEC \leftrightarrow A$
15	Faridi and Murtaza[65]	Pakistan	Y, K, L, EC, TO, G, A	ARDL	$EC \leftarrow Y, A$
16	Pao and Fu[49]	Brazil	REC, NRC, K, L	ARDL, VECM	$REC \rightarrow Y$
17	Mirza et al.[66]	Pakistan	IND, SE, EC, EP, TA	J–J, VECM	$EC \leftrightarrow IND$, $EC \leftrightarrow SE$, $TA \rightarrow IND, SE$

18	Abid and Mraihi[33]	Tunis	IND, SE, A, OC, EC, G, TC	J–J, VECM	$EC, G \rightarrow IND$
19	Rahman et al.[54]	Malaysia	IND, M, TE, EC, CC	ARDL, Y–T	$EC, CC \rightarrow M$

Note - GC: Granger causality, HC: Hsiao causality, J–J: Johansen and Juselius cointegration test, VECM: vector error correction method Granger causality, ARDL: Autoregressive distributive lagged modeling, Y–T: Yamamoto–Toda Granger causality, Y: economic growth measured by real GDP per capita, A: agriculture value added to GDP, M: manufacturing value added to GDP, IND: industrial value added to GDP, SE: service sector value added to GDP, TE: total energy consumption, PC: petroleum consumption, G: gas consumption, CC: coal consumption, EC: electricity consumption, AEC: electricity consumption in the agricultures sector, E: employment, EP: electricity prices, GP: gas prices, OP: oil prices, TA: technical efficiency, L: labor, K: capital, TO: total oil consumption, REC: renewable energy consumption, NRC: non-renewable energy consumption.

2.2 Financial Development and Electricity Consumption

Researchers have extensively studied the relationship between financial development and energy (electricity) consumption. These studies reveal how financial development contributes to energy consumption. [ix] For instance, financial development encourages foreign capital inflows via financial reforms. A developed financial sector provides cheaper domestic credit to the private sector (consumer and producer). Financial development stimulates banking sector activity and performance of stock markets[67]. The existing literature also addresses the relationship between financial development and energy consumption, which includes the energy demand function and production function[68]. For example, Mielnik and Goldemberg[69] use FDI as an indicator of financial development and report that financial development causes a decline in energy demand by adopting modern technology in the production process. Love and Zicchino[70] reveal that financial development affects real investment via financial sector policies that result in energy consumption. Mankiw and Scarth[71] note that stock market development diversifies risk by encouraging appropriate portfolio selection, which boosts the confidence of consumers and producers. This further stimulates economic activity, creating energy demand. For the Chinese economy, Dan and Lijun[72] empirically examine the link between financial development and primary energy consumption. They also find a unidirectional causal relationship running from financial development to primary energy consumption. In contrast, Shahbaz et al.[73] report that financial development is the cause of energy consumption in the Granger sense for the Chinese economy. Sadorsky[25] explores the relationship between financial development and energy demand by including other factors such as economic growth and energy prices in the energy demand function for emerging economies.

The empirical results show that economic growth stimulates energy demand. Financial development has a positive effect on energy consumption. Similarly, Sadorsky[26] investigates the relationship between financial development and energy consumption by including oil prices and economic growth as additional determinants in the energy demand function for Central and Eastern Europe. The results show that bank-based and stock market-based financial indicators spur energy consumption. Zhang et al.[74] examine the impact of stock market capitalization on energy consumption for the period of 1992-2009. Their results show that stock market scale enlargement is a bigger contributor to energy consumption compared to stock market efficiency. Shahbaz and Lean[75] analyze the relationship between financial development and energy consumption by incorporating industrialization and urbanization as additional determinants of financial development and energy consumption for the Tunisian economy. They find that financial development leads to industrialization that enhances energy demand. Their empirical analysis also indicates the feedback effect between financial development and energy consumption.

Islam et al.[76] use the multivariate energy demand function by incorporating economic growth and population growth to examine the relationship between financial development and energy consumption in Malaysia. They find that the variables are cointegrated, and financial development has a positive impact on energy consumption. Their causality analysis validates the presence of bidirectional causality between financial development and energy consumption. Tang et al.[77] estimate the energy demand function by incorporating trade openness and FDI. After finding cointegration between the variables, they note that while financial development increases energy consumption, economic growth is a major contributor to energy consumption for the Portuguese economy. They further report that electricity consumption is the cause of financial development in the Granger sense. Similarly, Ersoy and Unlu[78] study the linkage between stock market development and energy consumption in the Turkish economy for the period of 1995-2011. Their results reveal cointegration between stock market development and energy consumption, but unidirectional causality also runs from stock market development to energy consumption. Similarly, Al-mulali and Lee[79] analyze the Gulf Cooperation Council (GCC) countries' data to examine the linkage between financial development and energy demand for the period of 1980-2009 by including urbanization as an additional determinant. Their results show that financial development affects energy consumption positively and the feedback effect exists: financial development is the cause of energy consumption and vice versa in a Granger sense. Çoban and Topcu[80] note the positive role of financial development in energy demand stimulation for the European region. Aslan et al.[81] use a panel of Middle Eastern countries to examine the relationship between banking sector development and energy consumption for the period of 1980-2011 by applying the fully modified ordinary least squares (FMOLS) approach. Their analysis shows that banking sector development stimulates energy demand. They also note that banking sector development causes energy consumption and vice versa in a Granger sense. Zeren and Koc[82] apply the asymmetric causality test to examine the relationship between financial development and energy demand in newly industrialized economies. Their empirical evidence shows that financial development causes energy consumption, and the result is validated by the Hacker–Hatemi causality test. Their results reveal that positive shock in financial development causes energy consumption in India, Malaysia, Mexico, and Turkey, but negative shocks in financial development create energy consumption in Thailand. In a comparative study, Mallick and Mahalik[83] empirically investigate the link between financial development and energy demand in India and China, and find that financial development reduces energy demand.

Le[67] examines the data of Sub-Saharan African countries by employing an augmented production function, incorporating financial development and trade openness as additional determinants of economic growth and energy consumption. The results indicate that trade openness strengthens financial development, which creates energy demand, and energy consumption is the cause of economic growth in middle- and low-income countries. Kumar et al.[84] revisit the relationship between energy consumption and economic growth by adding financial development as an additional determinant in the production function. They note that the variables show cointegration in the long run, and energy consumption positively affects economic growth. Additionally, financial development affects economic growth, which increases energy consumption. Using the data of Asian countries for the period of 1980-2012,[x] Furuoka[68] examines the linkage between financial development and energy consumption by applying Dumitrescu and Hurlin's causality test[85]. The empirical results show that financial development is the cause of energy consumption. Chang[86] uses data from 53 developed and developing economies for the period of 1980-1999 to test the relationship between financial development and energy consumption by applying linear and non-linear specifications. The empirical evidence indicates a positive effect of financial development and economic growth on energy consumption. The results further show that financial development reduces energy consumption due to technological advancements. For GCC countries, Salahuddin et al.[87] examine the relationship between financial development and electricity consumption by applying dynamic ordinary least squares (OLS) and FMOLS for long-run associations. They find that economic growth and financial development lead to electricity consumption in the long run. Destek[88] uses Turkish time series data to explore the relationship between financial development and energy consumption by applying the Maki cointegration approach. The results show that financial development reduces energy demand, and energy consumption is the cause of financial development. In contrast, Altay and Topcu[89] report a neutral effect between financial development and energy demand. For Pakistan, Faridi and Murtaza[65] apply the production function to investigate the relationship between energy consumption and economic growth by incorporating interest rate in aggregate levels and agricultural credit in disaggregate levels.[xi] A summary of previous work on the nexus between financial development and energy consumption is shown in Table-2.

Table-2: Selected Studies on Finance-Energy Nexus

No.	Study	Country	Variables	Techniques	Findings
1	Dan and Lijun[72]	China	PEC, FD	GC	$ENC \rightarrow FD$
2	Sadorsky[25]	Emerging economies	Y, FD, ENC, EP	SGMM	FD leads ENC
3	Sadorsky[26]	CEE countries	Y, FD, ENC, EP	GMM	FD leads ENC
4	Zhang et al.[74]	China	SMD, ENC	GC	$ENC \leftarrow SMD$
5	Shahbaz and Lean[75]	Tunisia	ENC, Y, IND, U	ARDL, VECM	$ENC \leftrightarrow FD$
6	Islam et al.[76]	Malaysia	ENC, FD, Y, P	ARDL, VECM	$ENC \leftrightarrow FD$
7	Tang et al.[77]	Portugal	EC, FD, Y, RP, FDI, OP	ARDL, VECM	$EC \leftarrow FD$
8	Ersoy and Unlu[78]	Turkey	SMI, ENC	J–J, GC	$EC \leftarrow FD$
9	Al-mulali and Lee[79]	GCC countries	ENC, FD, Y, U, OP	DOLS, VECM	$ENC \leftrightarrow FD$
10	Faridi and Murtaza[65]	Pakistan	ENC, IR, Y	ARDL	IR declines ENC
11	Çoban and Topcu[80]	EU countries	ENC, Y, FD, EP	SGMM	FD leads ENC
12	Zeren and Koc[82]	N I countries	FD, ENC	H–H GC	Mixed results
13	Aslan et al.[81]	Middle Eastern countries	ENC, Y, EP, BD	FMOLS, VECM	$ENC \leftrightarrow FD$
14	Mallick and Mahalik[83]	India, China	FD, ENC, Y, U	ARDL	FD declines ENC
15	Chang[86]	53 countries	Y, ENC, FD, EP	PTM	FD leads ENC
16	Furuoka[68]	Asian countries	ENC, FD, FDI, Y	PFM, PC	$ENC \rightarrow FD$
17	Altay and Topcu[89]	Turkey	FD, ENC, Y	J–J, VECM	$EC \neq FD$
18	Destek[88]	Turkey	ENC, FD, EP, Y	M, VECM	$EC \leftarrow FD$
19	Ali et al.[90]	Nigeria	FD, EC, EP	ARDL, VECM	FD declines ENC
20	Kumar et al.[84]	South Africa	Y, ENC, FD, OP	ARDL, J–J, B–H, T–Y	$EC \neq FD$
21	Salahuddin et al.[87]	GCC countries	EC, E, FD, Y	DFE, MG, VECM	$EC \neq FD$

22	Le [91]	African countries	Y, ENC, FD, OP	MG, GC	$ENC \leftrightarrow FD$
23	Komal and Abbas[92]	Pakistan	FD, Y, ENC, EP, U, I, GC	GMM	FD leads ENC
24	Rashid[93]	Pakistan	FD, EC, FDI, Y	J–J, VECM	$EC \leftarrow FD$
25	Shahbaz[94]	Pakistan	Y, EC, FD, K	ARDL, VECM	$EC \leftrightarrow FD$

Note - GC: Granger causality, SGMM: system generalized method of moments estimator, ARDL: autoregressive distributive lag modeling, VECM: vector error correction method, J–J: Johansen and Juselius cointegration test, DOLS: dynamic ordinary least squares, HH: Hacker–Hatemi bootstrap Granger causality, FMOLS: fully modified ordinary least squares, PTM: panel threshold model, M: Maki structural break cointegration, DFE: dynamic fixed effects, MG: mean group estimation, PFM: panel fully modified, PC: panel causality, PEC: primary energy consumption, FD: financial development measures by domestic credit to the private sector as a share of the GDP, ENC: energy consumption, EP: energy prices, SMD: stock market development measures by stock market capitalization, Y: economic growth measured by real GDP per capita, IND: industrial value added to GDP, U: urbanization, P: population, EC: electricity consumption, RP: relative prices, FDI: foreign direct investment, OP: trade openness, SMI: stock market index, I: investment, GC: government size measures by government consumption expenditure, IR: real interest rate measure of financial development.

More recently, Rashid[93] applied the augmented energy demand function by incorporating financial development and FDI as additional contributors to energy consumption for Pakistan. The empirical results indicate that electricity consumption affects economic growth and financial development positively. Moreover, FDI, financial development, and economic growth cause electricity consumption in a Granger sense. Komal and Abbas[92] apply the GMM estimation approach to test the impact of financial development on energy consumption. Their authors show that financial development spurs economic growth (i.e., the supply-side effect).

3. Empirical Model and Data Collection

The association between electricity consumption and economic growth has been investigated extensively using the production function but with mixed results. For example, several researchers have investigated the relationship between electricity consumption and economic growth for many countries[5,8,9,95-102]. However, the results are mixed owing to the omission of financial development. Financial development plays a vital role in stimulating economic growth, which affects electricity demand[26]. To bridge this gap, this study investigates the electricity-growth nexus at the aggregate and sectoral levels by including financial development in the augmented production function as a potential determinant of electricity consumption and economic growth. The functional form of the augmented production function is modeled as follows:

$$Y_t = f(E_t, F_t, K_t, L_t) \tag{1}$$

We model the augmented production function into the empirical form (log-linear specification) by transforming all the variables into logarithms. The transformation of variables into the log-linear specification increases the reliability of the empirical results[77]. The functional form of the empirical equation is modeled as follows:

$$\ln Y_t = \beta_1 + \beta_E \ln E_t + \beta_F \ln F_t + \beta_K \ln K_t + \beta_L \ln L_t + \mu_i \tag{2}$$

where, Y_t, E_t, F_t, K_t, and L_t are economic growth, electricity consumption, financial development, capital, and labor, respectively. Natural-log is depicted by $\ln$, and μ_i is the error term with a normal distribution. Economic growth, financial development, and electricity consumption are measured by real GDP per capita, real domestic to private sector per capita, and electricity use per capita respectively. Real gross fixed capital formation is a measure for capital, and labor force per capita measures labor.[xii]

The data at the aggregate level, such as real GDP (local currency), electricity consumption (kWh), domestic credit to the private sector (local currency), gross fixed capital formation (local currency), and labor, are obtained from World Development Indicators[103]. We use total population data to transform these series into per capita terms. The study period is from 1972-2014. The data on the disaggregate level (namely, agriculture value-added to GDP, industrial value-added to GDP, and services value-added to GDP) are collected by the Government of Pakistan[104]. Financial development at the sectoral levels is measured by loans to the agriculture sector, loans to the industrial sector, and commercial loans to the services sector[104,xiii]

Sectoral electricity consumption data (by agriculture, industry, and services) are obtained from Pakistan Energy Statistical Year Book[105], and sectoral gross fixed capital formation and labor data are sourced from the Government of Pakistan[104].

4. Methodology

4.1 Combined Cointegration Approach

The cointegration relationship between the variables is investigated by applying the combined cointegration test developed by Bayer and Hanck[38]. Initially, Engle and Granger[106] developed the residual-based cointegration test that provides inefficient empirical results if the estimate of the cointegrating vector is not normally distributed. Engle and Yoo[107] solved this issue by developing a new test, which provides better and efficient empirical results owing to its explanatory power and size. The test by Phillips and Hansen[108] is also used to eliminate bias in the OLS estimates. However, Inder[109] criticizes the Phillips and Hansen[108] test and prefers to apply the FMOLS for long-run estimates compared to estimates of the UECM. Similarly, Johansen and Juselius' maximum likelihood results[110] are also sensitive if the variables are exogenous and endogenous. Pesaran et al.[111] suggest using the autoregressive distributive lag (ARDL) model or bounds testing approach to scrutinize the long-run relationship between the series. This approach is applicable if the series are integrated at I(1) or I(0) or I(1)/I(0). The main problem with ARDL bounds testing is that this approach provides efficient and reliable results once a single-equation cointegration relation exists between the variables; otherwise, the results are misleading.

Thus, we note that all these approaches have different theoretical backgrounds and produce conflicting results. Therefore, it is difficult to obtain uniform results because one cointegration test rejects the null hypothesis but another accepts it. Engle and Granger[106] suggest the residual-based test, Johansen[112] uses a system-based test, and Banerjee et al.[113] suggest employing lagged error correction-based approaches to cointegration. Pesavento[114] argues that the power of ranking cointegration approaches is sensitive to the value of nuisance estimators. Accordingly, Bayer and Hanck[38] develop a new approach by combining all the non-cointegrating tests to obtain uniform and reliable results. This approach provides efficient estimates by ignoring the nature of multiple testing procedures. Thus, non-combining cointegration tests provide robust and efficient results compared to individual t-tests or system-based tests. Thus, Bayer and Hanck[38] follow Fisher's formula[115] to combine the statistical significance level, that is, the *p*-values of a single test and the formulas given below:

$$EG-JOH=-2[\ln(P_{EG})+\ln(P_{JOH})] \tag{3}$$

$$EG-JOH-BO-BDM=-2[\ln(P_{EG})+\ln(P_{JOH})+\ln(P_{BO})+\ln(P_{BDM})] \tag{4}$$

The *p*-values of different individual cointegration tests[106,112,113,116] are denoted by P_{EG}, P_{JOH}, P_{BO}, and P_{BDM}, respectively. To determine whether cointegration exists between the variables, we follow Fisher's statistic. We may conclude in favor of cointegration by rejecting the null hypothesis of no cointegration once the critical values generated by Bayer and Hanck[38] are less than those calculated by Fisher's statistics, and vice versa.

4.2 The VECM Granger Causality

The presence of cointegration leads us to examine the causal association between the variables. Granger[117] argues that at least unidirectional causality should exist once the variables are cointegrated using a unique order of integration. In such a situation, the VECM Granger causality, which provides the direction of causal association between the variables in the short and long run[117] is suitable. The functional form of the VECM Granger causality is modeled as follows:

$$\begin{aligned}\Delta\ln Y_t &= \beta_{10}+\sum_{i=0}^{l}\beta_{11}\Delta\ln Y_{t-i}+\sum_{i=0}^{l}\beta_{12}\Delta\ln E_{t-i}+\sum_{j=0}^{m}\beta_{13}\Delta\ln F_{t-j}+\sum_{k=0}^{n}\beta_{14}\Delta\ln K_{t-k}\\ &+\sum_{r=0}^{o}\beta_{15}\Delta\ln L_{r-t}+D_t+\eta_1 ECT_{t-1}+\mu_{1i}\end{aligned} \tag{5}$$

$$\Delta\ln E_t = \beta_{20} + \sum_{i=0}^{l}\beta_{21}\Delta\ln E_{t-i} + \sum_{i=0}^{l}\beta_{22}\Delta\ln Y_{t-i} + \sum_{j=0}^{m}\beta_{23}\Delta\ln F_{t-j} + \sum_{k=0}^{n}\beta_{24}\Delta\ln K_{t-k} + \sum_{r=0}^{o}\beta_{25}\Delta\ln L_{r-t} + D_t + \eta_2 ECT_{t-1} + \mu_{2i} \tag{6}$$

$$\Delta\ln F_t = \beta_{30} + \sum_{i=0}^{l}\beta_{31}\Delta\ln F_{t-i} + \sum_{i=0}^{l}\beta_{32}\Delta\ln Y_{t-i} + \sum_{j=0}^{m}\beta_{33}\Delta\ln E_{t-j} + \sum_{k=0}^{n}\beta_{34}\Delta\ln K_{t-k} + \sum_{r=0}^{o}\beta_{35}\Delta\ln L_{r-t} + D_t + \eta_3 ECT_{t-1} + \mu_{3i} \tag{7}$$

$$\Delta\ln K_t = \beta_{40} + \sum_{i=0}^{l}\beta_{41}\Delta\ln K_{t-i} + \sum_{i=0}^{l}\beta_{42}\Delta\ln Y_{t-i} + \sum_{j=0}^{m}\beta_{43}\Delta\ln E_{t-j} + \sum_{k=0}^{n}\beta_{44}\Delta\ln K_{t-k} + \sum_{r=0}^{o}\beta_{45}\Delta\ln L_{r-t} + D_t + \eta_4 ECT_{t-1} + \mu_{4i} \tag{8}$$

$$\Delta\ln L_t = \beta_{50} + \sum_{i=0}^{l}\beta_{51}\Delta\ln L_{t-i} + \sum_{i=0}^{l}\beta_{52}\Delta\ln Y_{t-i} + \sum_{j=0}^{m}\beta_{53}\Delta\ln E_{t-j} + \sum_{k=0}^{n}\beta_{54}\Delta\ln F_{t-k} + \sum_{r=0}^{o}\beta_{55}\Delta\ln K_{r-t} + D_t + \eta_5 ECT_{t-1} + \mu_{5i} \tag{9}$$

The difference operator is depicted by Δ, and η_s is the coefficient of the lagged error term ECT_{t-1}, which is derived from the long-run association regression. The $\varepsilon_{1t}, \varepsilon_{2t}, \varepsilon_{3t}, \varepsilon_{4t}$, and ε_{5t} are error terms assumed to have normal distributions. The statistical significance of ECT_{t-1} with a negative sign validates the presence of long-run causality. For short-run causality, the Wald test is applied on the first differences of the variables. For example, $B_{12} \neq 0\forall_i$ indicates the presence of causality running from electricity consumption to economic growth in the short run. In the short run, causality running from economic growth to electricity consumption is shown by $B_{21} \neq 0\forall_i$.

5. Empirical Results and Discussion

The ADF unit root test is applied to test the stationarity level of the variables. The empirical results are show in Table-3. We note that all the series show a unit root problem with the intercept and time trend. After first differencing, the series are stationary. This indicates the unique level of integration. We conclude that economic growth (agriculture, industrial, services sectors), electricity consumption (agriculture, industrial, services sectors), capital (agriculture, industrial, services sectors), and labor (agriculture, industrial, and services sectors) are integrated at I(1). The augmented Dickey–Fuller (ADF) and Phillips–Perron (PP) unit root tests ignore the information of structural breaks occurring in the series because of the implementation of economic reforms undertaken to improve the performance of macroeconomic variables. We overcome this issue by applying Zivot and Andrews' (ZA) technique[118] which contains information on a single unknown structural break in the series.

Table-3: Unit Root Analysis without Structural Breaks

Variable	ADF Test at Level		ADF Test at First Difference	
	T-Statistic	Prob.	T-Statistic	Prob.
	Agriculture Sector			
$\ln Y_t$	-2.2080 (2)	0.2048	-4.5157 (2) *	0.0046
$\ln E_t$	-1.4336 (1)	0.8357	-4.5190 (1) *	0.0044
$\ln F_t$	-0.7752 (1)	0.9597	-4.3638 (2) *	0.0066
$\ln K_t$	-2.0629 (2)	0.5503	-5.0129 (3) *	0.0012
$\ln L_t$	0.0402 (3)	0.9945	-4.4935 (1) *	0.0047
	Industry Sector			
$\ln Y_t$	-2.2414 (2)	0.3541	-3.6854 (2) **	0.0351
$\ln E_t$	-1.8218 (1)	0.6758	-3.5580 (1) **	0.0463
$\ln F_t$	-2.5524 (2)	0.3020	-4.4382 (2) *	0.0069
$\ln K_t$	-2.9326 (2)	0.1636	-3.8759 (2) **	0.0227
$\ln L_t$	-0.3789 (3)	0.9852	-3.5446 (1) **	0.0481
	Services Sector			
$\ln Y_t$	-2.4542 (1)	0.3479	-5.1037 (2) *	0.0009
$\ln E_t$	-2.3167 (2)	0.4157	-5.5776 (1) *	0.0002
$\ln F_t$	-2.6676 (1)	0.2546	-4.8174 (2) *	0.0020

$\ln K_t$	-2.9058 (2)	0.1713	-5.5263 (1) *	0.0002
$\ln L_t$	-1.5416 (1)	0.7983	-6.1975 (2) *	0.0000
	Aggregate Level			
$\ln Y_t$	-2.4828 (1)	0.1911	-4.2178 (2) *	0.0078
$\ln E_t$	-2.8838 (2)	0.1780	-6.0842 (1) *	0.0001
$\ln F_t$	-3.1176 (3)	0.1173	-4.2184 (2) *	0.0098
$\ln K_t$	-3.1193 (2)	0.1155	-5.7239 (1)*	0.0002
$\ln L_t$	0.9157 (1)	0.9989	-3.9624 (2) **	0.0183

Note: Significance at 1% and 5% is indicated by * and **, respectively.

The results of the ZA unit root tests are shown in Table-4. We note that economic growth, electricity consumption, capital, and labor at the sectoral levels show a unit root problem with intercept and trend at level, and there are structural breaks in the variables. Economic growth, electricity consumption, financial development, capital, and labor show the presence of structural breaks for the years 2005, 1999, 1985, 2005, and 2002, respectively. The Government of Pakistan implemented numerous economic reforms to improve macroeconomic performance for the sampled period. During the period 2003-2004, the adoption of the Agriculture Prospective and Policy (APP) in the agriculture sector and the privatization policy in the industrial sector affected growth rates. The contribution of these sectors to the GDP was 44.4% in 2005. The implementation of the National Mineral Policy (NMP) in 1995 influenced Pakistan's services sector. In 2004, Pakistan adopted a liberalization program and privatized many banks and other industries to encourage private sector economic activity, which affected economic growth in 2005[119]. The results show the same integration level after first differencing. We note that all the variables are integrated at I(1). We find that the results provided by the ZA test confirm the robustness of the unit root analysis.

Table-4: Unit Root Analysis with Structural Breaks

Variable	ZA Test at Level		ZA Test at First Difference	
	T-Statistic	Break Year	T-Statistic	Break Year
	Agriculture Sector			
$\ln Y_t$	-4.470 (1)	2005	-8.392 (2) *	2005
$\ln E_t$	-3.953 (2)	1999	-7.150 (3) *	2002
$\ln F_t$	-3.396 (1)	1985	-6.887 (2) *	2010
$\ln K_t$	-4.847 (3)	2005	-10.072 (1) *	1982
$\ln L_t$	-4.987 (2)	2002	-8.901 (2) *	2004
	Industry Sector			
$\ln Y_t$	-3.618 (1)	2005	-5.501 (2) **	2004
$\ln E_t$	-4.386 (2)	1994	-5.481 (1) **	1993
$\ln F_t$	-4.216 (3)	2003	-7.320 (2) *	2003
$\ln K_t$	-4.021 (1)	2005	-6.578 (1) *	1981
$\ln L_t$	-4.655 (2)	1993	-9.745 (2) *	1996
	Services Sector			
$\ln Y_t$	-3.317 (2)	1996	-6.635 (1) *	2005
$\ln E_t$	-2.884 (1)	2008	-8.814 (2) *	2008
$\ln F_t$	-3.951 (1)	1981	-7.302 (3) *	2003
$\ln K_t$	-3.189 (2)	1980	-8.170 (2) *	1998
$\ln L_t$	-3.023 (1)	2000	-13.352 (1) *	2002
	Aggregate Level			
$\ln Y_t$	-4.221 (1)	2005	-6.592 (2) *	2005
$\ln E_t$	-2.007 (2)	2008	-13.249 (1) *	2009
$\ln F_t$	-4.173 (3)	2005	-7.743 (2) *	2003
$\ln K_t$	-4.336 (1)	1980	-9.503 (2) *	1982
$\ln L_t$	-3.890 (2)	2000	-8.889 (3) *	1993

Note: Significance at 1% and 5% is indicated by * and **, respectively.

The results of the ADF and ZA unit root tests show that all the variables are stationary at first differencing, that is, I(1). The unique integrating order of the variables allows us to apply Bayer and Hanck's combined cointegration approach[38] to examine the existence of cointegration between the variables at the aggregate and sectoral levels. The Bayer–Hanck combined cointegration approach is suitable and provides reliable empirical results compared to traditional cointegration approaches. The results are shown in Table-5.[xiv] At the aggregate level, we note that the calculated Fisher statistics of the EG-JOH and EG-JOH-BO-BDM tests are greater than the critical values of the EG-JOH and EG-JOH-BO-BDM tests at the 1% level of significance as we treat economic growth, electricity consumption, financial development, and capital as dependent variables. This may lead us to reject the null hypothesis, that is, no cointegration. The rejection of the null hypothesis indicates the presence of cointegration between the variables.

The results of the agriculture and services sectors are similar to those of the aggregate level, but the findings for the industrial sector differ slightly. For the industrial sector, we note that the estimated Fisher statistics of the EG-JOH-BO-BDM tests are greater than the critical values of the EG-JOH and EG-JOH-BO-BDM tests as economic growth, electricity consumption, and capital are used as dependent variables. This leads us to reject the null hypothesis, namely, no cointegration. We find cointegration between the variables as we employ economic growth, electricity consumption, and capital as dependent variables. This shows the existence of cointegration between economic growth, electricity consumption, financial development, capital, and labor at the aggregate and sectoral levels.

Table-5. Bayer and Hanck Cointegration Analysis

Estimated Models	EG-JOH	EG-JOH-BO-BDM	Lag Order	Cointegration
	Agriculture Sector			
$Y_t = f(EC_t, F_t, K_t, L_t)$	21.467 *	32.658 *	2	Yes
$EC_t = f(Y_t, F_t, K_t, L_t)$	22.202 *	43.270 *	2	Yes
$F_t = f(Y_t, EC_t, K_t, L_t)$	23.292 *	35.078 *	2	Yes
$K_t = f(Y_t, EC_t, F_t, L_t)$	22.840 *	31.470 **	2	Yes
$L_t = f(Y_t, EC_t, F_t, K_t)$	1.525	4.324	2	No
	Industrial Sector			
$Y_t = f(EC_t, F_t, K_t, L_t)$	19.645 *	36.336 *	2	Yes
$EC_t = f(Y_t, F_t, K_t, L_t)$	18.254 *	38.721 *	2	Yes
$F_t = f(Y_t, EC_t, K_t, L_t)$	7.332	9.267	2	No
$K_t = f(Y_t, EC_t, F_t, L_t)$	16.560 *	38.226 *	2	Yes
$L_t = f(Y_t, EC_t, F_t, K_t)$	7.543	17.644	2	No
	Services Sector			
$Y_t = f(EC_t, F_t, K_t, L_t)$	17.440 *	38.240 *	2	Yes
$EC_t = f(Y_t, F_t, K_t, L_t)$	20.957 *	35.705 *	2	Yes
$F_t = f(Y_t, EC_t, K_t, L_t)$	23.200 *	33.391 *	2	Yes
$K_t = f(Y_t, EC_t, F_t, L_t)$	15.924 *	37.895 *	2	Yes
$L_t = f(Y_t, EC_t, F_t, K_t)$	4.040	5.561	2	No
	Aggregate Level			
$Y_t = f(EC_t, F_t, K_t, L_t)$	24.059 *	36.190 *	2	Yes
$EC_t = f(Y_t, F_t, K_t, L_t)$	24.047 *	34.571 *	2	Yes
$F_t = f(Y_t, EC_t, K_t, L_t)$	23.180 *	33.582 *	2	Yes
$K_t = f(Y_t, EC_t, F_t, L_t)$	16.327 *	36.393 *	2	Yes
$L_t = f(Y_t, EC_t, F_t, K_t)$	5.203	14.450	2	No

Note: * denotes significance at 1%. The critical values at the 1% level are 15.845 (EG-JOH) and 30.774 (EG-JOH-BO-BDM). Lag length is based on the AIC.

The empirical findings provided by Bayer and Hanck's combined cointegration approach[38] may be ambiguous. The reason is that combined cointegration fails to accommodate information concerning unknown structural breaks in the series. Pakistan implemented numerous economic reforms to improve the performance of the agriculture, industry, and services sectors and their aggregate level. These reforms affected sectoral growth and aggregate economic growth in Pakistan[119]. The subject of structural breaks is addressed by incorporating the break point dummy following the ZA unit root test while applying the bounds testing approach for the determination of the cointegration relationship between the variables. The optimal lag order is chosen following the Akaike information criterion (AIC) for the calculation of the ARDL F-statistic because the ARDL F-statistic is sensitive to the selection of lag order. Both results appear in Table-6.[xv] We note that at the aggregate level, the computed ARDL F-statistics are greater than the upper critical bounds, using economic growth, electricity consumption, financial development, and capital as the dependent variables. This indicates the presence of four cointegrating vectors and leads us to reject the null hypothesis. We infer that cointegration exists at the aggregate level between the variables for the sampled period.

The empirical findings at the sectoral levels are also interesting. We have four cointegration vectors as we use economic growth, electricity consumption, and capital as dependent variables in the agriculture and services sectors. The analysis accepts the hypothesis of cointegration between the variables, and we have three cointegrating vectors as economic growth, electricity consumption, and capital are used as the dependent variables for the agriculture sector. This confirms the presence of a cointegration relationship between the variables. Based on the results, we surmise that economic growth, electricity consumption, financial development, capital, and labor show cointegration both at the aggregate and the sectoral levels. This further indicates that the ARDL bounds testing provides robust and consistent results compared to Bayer and Hanck's approach[38].

Table-6: Results of the ARDL Cointegration Test

Bounds Testing to Cointegration			Diagnostic tests					
Estimated Models	Lag Length	F-Statistic	Break Year	χ^2_{NORMAL}	χ^2_{ARCH}	χ^2_{RESET}	CUSUM	CUSUMsq
	Agriculture Sector							
$Y_t = f(EC_t, F_t, K_t, L_t)$	2, 2, 1, 1, 2	8.116 **	2005	0.1301	0.2156	0.3255	Stable	Stable
$EC_t = f(Y_t, F_t, K_t, L_t)$	2, 2, 2, 1, 1	8.725 *	1999	0.4195	0.1305	0.7500	Stable	Stable
$F_t = f(Y_t, EC_t, K_t, L_t)$	2, 2, 2, 2, 1	12.082 *	1985	0.4939	1.2666	0.9448	Stable	Stable
$K_t = f(Y_t, EC_t, F_t, L_t)$	2, 2, 1, 2, 2	5.941 ***	2005	3.0180	0.1072	0.6992	Stable	Stable
$L_t = f(Y_t, EC_t, F_t, K_t)$	2, 2, 2, 2, 2	3.843	2002	0.1427	0.0675	0.6347	Unstable	Stable
	Industrial Sector							
$Y_t = f(EC_t, F_t, K_t, L_t)$	2, 2, 1, 1, 2	9.525 *	2005	0.9335	0.0014	2.2466	Stable	Stable
$EC_t = f(Y_t, F_t, K_t, L_t)$	2, 2, 2, 1, 1	7.904 **	1994	0.3766	0.0004	1.2834	Stable	Stable
$F_t = f(Y_t, EC_t, K_t, L_t)$	2, 2, 2, 2, 1	1.089	2003	1.1694	0.0273	0.1618	Unstable	Stable
$K_t = f(Y_t, EC_t, F_t, L_t)$	2, 2, 1, 2, 2	10.911 *	2005	1.0473	0.2572	0.5460	Stable	Stable
$L_t = f(Y_t, EC_t, F_t, K_t)$	2, 2, 2, 2, 2	1.622	1993	1.2003	0.0654	0.1415	Stable	Unstable
	Services Sector							
$Y_t = f(EC_t, F_t, K_t, L_t)$	2, 2, 1, 1, 2	7.905 *	1996	0.8528	1.1686	2.3688	Stable	Stable

$EC_t = f(Y_t, F_t, K_t, L_t)$	2, 2, 2, 1, 1	10.700 *	2008	0.5749	0.0928	1.5866	Stable	Stable
$F_t = f(Y_t, EC_t, K_t, L_t)$	2, 2, 2, 2, 1	6.785 ***	1981	0.3160	0.5011	0.4388	Stable	Stable
$K_t = f(Y_t, EC_t, F_t, L_t)$	2, 2, 1, 2, 2	7.053 **	1980	0.4566	1.8523	2.5100	Stable	Stable
$L_t = f(Y_t, EC_t, F_t, K_t)$	2, 2, 2, 2, 2	1.572	2000	3.7846	2.5958	2.0440	Unstable	Unstable
	Aggregate Level							
$Y_t = f(EC_t, F_t, K_t, L_t)$	2, 2, 1, 1, 2	7.814 **	2005	1.4098	0.6098	2.9494	Stable	Stable
$EC_t = f(Y_t, F_t, K_t, L_t)$	2, 2, 2, 1, 1	7.433 **	2008	0.1048	0.0164	1.7624	Stable	Stable
$F_t = f(Y_t, EC_t, K_t, L_t)$	2, 2, 2, 2, 1	9.261 *	2005	0.0637	2.5167	1.5967	Stable	Stable
$K_t = f(Y_t, EC_t, F_t, L_t)$	2, 2, 1, 2, 2	13.671 *	1980	0.2488	0.0013	0.6727	Stable	Stable
$L_t = f(Y_t, EC_t, F_t, K_t)$	2, 2, 2, 2, 2	1.405	2000	0.8578	0.3134	0.3334	Stable	Unstable

Significant level	Critical Values	
	Lower bounds $I(0)$	Upper bounds $I(1)$
1 per cent level	7.317	8.720
5 per cent level	5.360	6.373
10 per cent level	4.437	5.377

Note: * and ** denote significance at 1 and 5 per cent, respectively. The optimal lag length is determined by the AIC. Critical values are sourced from Narayan [120].

In the long-run (Table-7, upper segment), at the aggregate level, electricity consumption is positively associated with economic growth. A 1% increase in electricity consumption increases economic growth by 0.028%. This finding is similar to previous results[10,37,56,57,121], wherein electricity consumption is recognized as an important driver of economic growth in Pakistan. Financial development adds significantly to economic growth. A 0.175% increase in economic growth is stimulated by a 1% increase in financial development. This finding is consistent with that of Shahbaz[122], who reports that financial development is a catalyst for real economic activity and, hence, economic growth. Jalil and Feridun[123] note that financial development stimulates economic growth by promoting total factor productivity. Similarly, Shahbaz et al.[73] report that financial development contributes to economic growth via trade openness for the Chinese economy. The effect of capitalization on economic growth is positive and significant at the 1% level. A 0.038% increase in economic growth is stimulated by a 1% increase in capitalization, all else being the same. Shahbaz[10] confirms that capital plays an important role in stimulating economic activity and, thus, economic growth. The relationship between labor and economic growth is positive and statistically significant. A 1% increase in labor boosts the GDP by 0.259%, keeping other things constant.

At the sectoral levels, electricity consumption has a positive and statistically significant effect on the growth of the agriculture, industry, and services sectors. A 1% % increase in electricity consumption raises economic growth by 0.243%, 0.420%, and 0.079% in the agriculture, industry, and service sectors, respectively. Financial development is positively and significantly linked with sectoral economic growth. Keeping all else the same, a 1% increase in financial development increases economic growth by 0.143%, 0.106%, and 0.189% in the agriculture, industry, and services sectors, respectively. This empirical finding is consistent with the results of Shahbaz et al.[124], who report that a 1% increase in financial development stimulates the agriculture sector's growth by 0.2712%. The impact of capital on agriculture growth and industrial growth is positive and significant, but capital reduces service sector growth, indicating the inefficient use of capital in the services sector. A 1% increase in capital in the agriculture and industrial sectors increases real output by 0.297% and 0.086%, respectively, but reduces real output in the services sector by 0.041%. The relationship between labor and economic growth (at the sectoral levels) is positive and significant. All else being the same, a 1.857%, 0.035%, and 0.15% increase in real output in the agriculture, industry, and services sectors is led by a 1% increase in labor. Labor affects the agriculture sector predominantly, owing to the sector's dependence on labor availability. The impact of dummy variable (APP) on agriculture output is negative and significant. This shows that the implementation of APP would not help the agriculture sector to improve its performance. On the contrary, adoption of liberalization and privatization polices impacts the industrial and service sectors positively and significantly. This shows that overall, economic policies affect economic growth positively and significantly. The empirical models at the aggregate and sectoral levels are free from autocorrelation and are statistically significant at the 1% level.

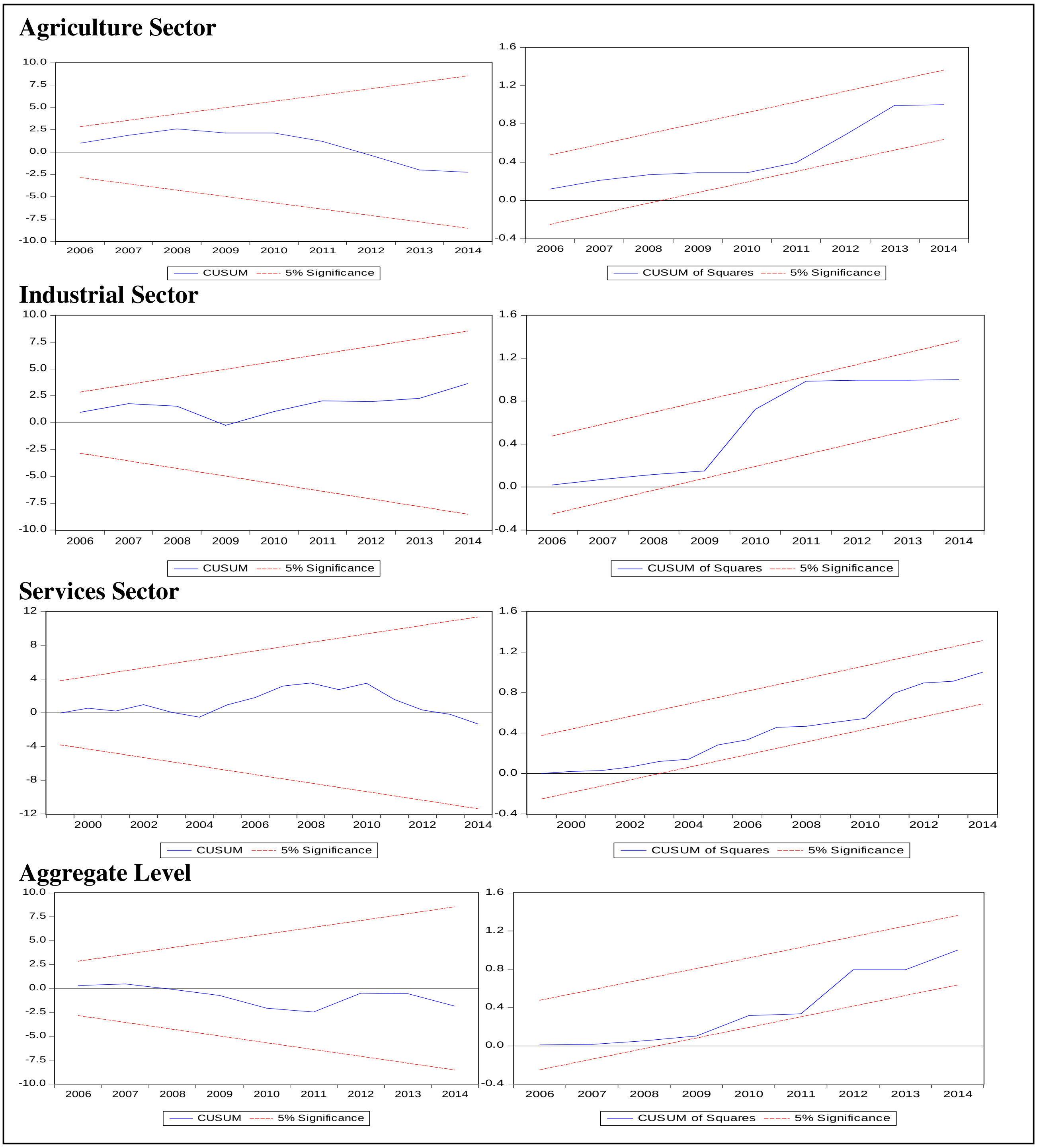
Table-7: Long-run and Short-run Analyses

Dependent Variable = $\ln Y_t$								
Long Run Analysis								
Variable	Coefficient	T-statistic	Coefficient	T-statistic	Coefficient	T-statistic	Coefficient	T-statistic
	Agriculture Sector		Industrial Sector		Services Sector		Aggregate Level	
Constant	9.607 *	17.262	5.203 *	25.884	7.670 *	32.865	9.590 *	31.879
$\ln E_t$	0.243 ***	1.923	0.420 *	8.822	0.079 *	3.992	0.028 **	2.511
$\ln F_t$	0.143 *	2.768	0.106 *	7.606	0.189 *	6.931	0.175 *	23.993
$\ln K_t$	0.297 *	5.324	0.086 *	4.000	-0.041 *	-3.808	0.038 *	4.118
$\ln L_t$	1.857 *	15.963	0.035 **	2.628	0.150 ***	1.894	0.259 *	3.623
DUM_t	-0.116 **	-2.011	0.167 *	5.682	0.036 **	2.260	0.132 *	6.418
D–W Test	1.809		1.843		1.771		1.641	
F-Statistic	92.897 *		100.658 *		31.656 *		127.613 *	
Short Run Analysis								
Constant	0.001	0.256	0.004	0.329	0.023 *	4.572	0.009	1.385
$\Delta\ln E_t$	-0.003	-0.165	0.400 **	2.797	0.004	0.431	0.002	0.253

$\Delta \ln F_t$	0.034 ***	1.813	0.088	1.027	0.043 **	2.149	0.095 ***	1.715
$\Delta \ln K_t$	-0.019 ***	-1.715	0.068**	1.795	-0.004	-0.914	-0.006	-1.378
$\Delta \ln L_t$	-0.239 **	-2.357	0.040	0.380	0.037	0.625	-0.403 **	-2.057
DUM_t	0.020	1.577	0.021	1.223	-0.004	-0.646	0.016	1.092
ECM_{t-1}	-0.254 ***	-1.872	-0.449 **	-2.000	-0.224 **	-2.446	-0.668 **	-2.523
D–W Test	1.9805		1.587		1.634		1.598	
F-Statistic	2.997 **		2.944 **		2.197 **		2.160 **	
Stability Analysis								
Test	**F-statistic**	**Prob.**	**F-statistic**	**Prob.**	**F-statistic**	**Prob.**	**F-statistic**	**Prob.**
χ^2 *NORAL*	0.3271	0.8491	0.6747	0.7136	0.6000	0.7245	1.5852	0.4526
χ^2 *SERIAL*	0.0693	0.9232	1.1137	0.3411	0.2637	0.7697	2.0466	0.1443
χ^2 *ARCH*	0.7226	0.5453	0.0805	0.7781	0.2673	0.6080	0.0066	0.9354
χ^2 *HETERO*	0.6123	0.8609	1.0283	0.4153	0.2955	0.9350	1.1433	0.3758
χ^2 *REMSAY*	1.3076	0.2003	1.0200	0.2314	0.4721	0.3698	0.5234	0.3718
CUSUM	Stable	0.0500	Stable	0.0500	Stable	0.0500	Stable	0.0500
CUMSUMsq	Stable	0.0500	Stable	0.0500	Stable	0.0500	Stable	0.0500

Note: *, **, and *** show significance at the 1%, 5%, and 10% levels, respectively. D–W stands for Durbin–Watson test.

Figure-4. CUSUM and CUSUMsq



The short-run (Table-7, lower segment) results show that at the aggregate level, electricity consumption contributes to economic growth insignificantly. The impact of financial development on economic growth is positive and significant, but capital decreases domestic production insignificantly. The relationship between labor and economic growth is negative and significant. This shows that labor availability could not contribute to domestic economic activity owing to disguised unemployment in the economy. At the sectoral levels, electricity consumption adds to industrial growth significantly. Financial development boosts economic activity and, hence, the growth of agriculture and services sectors significantly. Capital is negatively (positively) linked with the agriculture and industrial sectors, respectively. The relationship between labor and industrial sector (services sector) growth is positive but statistically insignificant. Labor affects agricultural growth negatively and significantly. This shows that labor availability in the short run could not contribute to agriculture because of under-employment in that sector. The coefficients of the lagged error term (ECM_{t-1}) are statistically significant with negative signs. These estimates are -0.254, -0.449, -0.224, and -0.668 for the production function at the sectoral levels (the agriculture, industry, and services sectors) and aggregate level, respectively. The speed of adjustment from the short-run to the long-run equilibrium path is 25.4%, 44.9%, 22.4%, and 66.8% for the agriculture, industry, and services sectors, and the aggregate level production function, respectively.

We also conduct a diagnostic analysis. We find that empirical results are free from the problem of serial correlation, autoregressive conditional heteroscedasticity, White heteroscedasticity, and the specification of empirical models. The results show a normal distribution of error terms. We also apply the cumulative sum control chart (CUSUM) and CUSUM squared (CUSUMsq) tests to examine the efficiency and reliability of the short- and long-run parameters. The empirical results are shown in Figure-4. The lines depicting CUSUM and CUSUMsq for all empirical models lie between the critical bounds (red lines) at the 5% level. This confirms that the short-run and long-run parameters are stable and reliable.

Table-8. VECM Granger Causality Analysis

Dependent Variable	Type of Causality					
	Short Run					Long Run
	$\sum \Delta \ln Y_{t-1}$	$\sum \Delta \ln E_{t-1}$	$\sum \Delta \ln F_{t-1}$	$\sum \Delta \ln K_{t-1}$	$\sum \Delta \ln L_{t-1}$	ECT_{t-1}
	Agriculture Sector					
$\Delta \ln Y_t$	…	0.4858 [0.6201]	0.8682 [0.4303]	0.4504 [0.6417]	1.6567 [0.2083]	-0.219 *** [-1.754]
$\Delta \ln E_t$	0.6094 [0.5170]	…	2.7455 *** [0.0809]	0.3701 [0.6939]	1.2920 [0.2900]	-0.2695 ** [-2.3579]
$\Delta \ln F_t$	3.7664 ** [0.0351]	1.4927 [0.2415]	…	0.0099 [0.9901]	1.4151 [0.2592]	-0.2175 ** [-2.2521]
$\Delta \ln K_t$	0.1669 [0.8471]	1.3197 [0.2828]	0.3558 [0.7036]	…	2.8032 [0.0771]	-0.6292 ** [-2.3748]
$\Delta \ln L_t$	0.6107 [0.5495]	0.2344 [0.7924]	0.1314 [0.8773]	2.0241 [0.1498]	…	…
	Industrial Sector					
$\Delta \ln Y_t$	…	3.7224 ** [0.0487]	0.5999 [0.5797]	1.8541 [0.1753]	1.1287 [0.3377]	-0.4336 ** [-2.7126]
$\Delta \ln E_t$	1.7566 [0.1911]	…	0.9167 [0.4115]	0.0925 [0.9118]	2.2432 [0.1248]	-0.2896 ** [-2.4371]
$\Delta \ln F_t$	0.7842 [0.4659]	0.7545 [0.4834]	…	0.6354 [0.5369]	0.1628 [0.8505]	…
$\Delta \ln K_t$	8.0124 * [0.0018]	0.1154 [0.8914]	0.7945 [0.4613]	…	0.7545 [0.4795]	-0.5222 * [-4.6602]
$\Delta \ln L_t$	2.5756 *** [0.0940]	0.5739 [0.5698]	0.8340 [0.4448]	1.3778 [0.2687]	…	…
	Services Sector					
$\Delta \ln Y_t$	…	0.1910 [0.8271]	1.6793 [0.2036]	0.8439 [0.4399]	2.2356 [0.1244]	-0.2331 ** [-2.2091]

$\Delta \ln E_t$	0.3118 [0.7344]	…	0.1895 [0.8283]	0.0359 [0.9648]	1.3083 [0.2852]	-0.1139 * [-4.9292]
$\Delta \ln F_t$	3.9588 ** [0.0298]	0.1785 [0.8374]	…	0.3965 [0.6761]	2.6315 *** [0.0885]	-0.6859 * [-4.6677]
$\Delta \ln K_t$	1.7941 [0.1837]	0.2239 [0.8007]	0.7176 [0.4961]	…	2.1871 [0.1298]	-0.7450 * [-3.7620]
$\Delta \ln L_t$	6.7219 * [0.0038]	4.7735 ** [0.0156]	0.4334 [0.6459]	2.7720 *** [0.0781]	…	…
	Aggregate Level					
$\Delta \ln Y_t$	…	0.0404 [0.9604]	0.6151 [0.5475]	2.1011 [0.1405]	4.7095 ** [0.0169]	-0.6234 * [-2.7680]
$\Delta \ln E_t$	0.3005 [0.7427]	…	0.6379 [0.5356]	0.9587 [0.3952]	2.1081 [0.1397]	-0.1133 * [-5.9285]
$\Delta \ln F_t$	2.7682 *** [0.0794]	12.7138 * [0.0001]	…	5.5984* [0.0088]	2.2552 [0.1229]	-0.0854 ** [-2.5467]
$\Delta \ln K_t$	0.1920 [0.8263]	0.2562 [0.7756]	0.8127 [0.4535]	…	0.4727 [0.6280]	-0.7204 ** [-2.7492]
$\Delta \ln L_t$	6.0172 * [0.0063]	0.2758 [0.7608]	1.7657 [0.1884]	3.3651 ** [0.0480]	…	

Note: *, **, and *** denote the significance at the 1, 5, and 10 per cent level, respectively.

The next step is to determine the direction of the causal relationship between the variables for the long run and short run. The results of the electricity-growth nexus on the sectoral and aggregate levels are noted in Table-8. In the long run, the bidirectional causal relationship is noted between agriculture sector growth and electricity consumption. This finding is consistent with the results of Abbas and Choudhury[61] and Liew et al.[63], who report the feedback effect between both variables. In contrast, Jamil and Ahmad[57,58] document that the unidirectional causality runs from economic growth to electricity consumption in the agriculture sector, but Tang and Shahbaz[60] observe a neutral effect between both variables. A bidirectional causal relationship exists between financial development and economic growth in the agriculture sector. Similarly, Shahbaz et al.[124] reveal that financial development and economic growth in the agriculture sector are interdependent. The feedback effect also exists between financial development and agriculture electricity consumption. Capital Granger causes economic growth and economic growth Granger causes capital in the agriculture sector. The unidirectional causality runs from labor to economic growth, electricity consumption, financial development, and capital in the agriculture sector. For the industrial sector, the feedback effect exists between electricity consumption and economic growth. Contrarily, Jamil and Ahmad[58] and Liew et al.[63] note that electricity consumption is the Granger cause of economic growth in the industrial sector. Financial development causes economic growth, electricity consumption, and capital. Capital causes economic growth, and economic growth causes capital in the Granger sense, namely, there is bidirectional causality. The bidirectional causal relationship is also found between capital and electricity consumption. Labor Granger causes economic growth, electricity consumption, and capital in the industrial sector.

For services sector, economic growth is the cause of electricity consumption and vice versa in the Granger sense. The feedback effect is noted between financial development and electricity consumption, and a similar effect is true for financial development and economic growth. Bidirectional causality is found between capital and economic growth (electricity consumption). Unidirectional causality is noted to run from labor to economic growth, electricity consumption, financial development, and capital. At the aggregate level, economic growth and electricity consumption are interdependent, that is, we observe a bidirectional causal relationship. This finding is consistent with the results of previous studies[61,121,125], which validate the feedback effect between electricity consumption and economic growth. However, this empirical evidence is contradictory to some results[56-58,60,126,127]. This contradiction in empirical results may be due to the omission of relevant variables such as financial development, capital, and labor while investigating the production function. The feedback effect is also validated between financial development and electricity consumption. This empirical finding is consistent with the results of Shahbaz[10], who reports that the link between financial development and electricity consumption is bidirectional. Capital causes economic growth and economic growth causes capital in the Granger sense. A unidirectional causal relationship exists, running from labor to economic growth, electricity consumption, financial development, and capital.

In the short run, financial development causes electricity consumption and economic growth in the agriculture sector. For the industrial sector, economic growth is the cause of electricity consumption, capital, and labor. For services sector, the demand-side hypothesis is validated, that is, economic growth causes financial development. The relationship between financial development and labor is bidirectional. Economic growth, electricity consumption, and capital cause labor. At the aggregate level, the feedback effect is evident between labor and economic growth. The demand-side effect exists, namely, economic growth causes financial development. A unidirectional causality runs from electricity consumption and capital to financial development. Capital causes labor.

6. Concluding Remarks and Policy Implications

Pakistan has been facing a severe energy crisis since the last two decades: aggregate and sectoral economic growth have been affected. In such a situation, just investigating the direction of the causal relationship between electricity consumption and economic growth at the aggregate level would not be sufficient to help the country's energy policy framework to enable sustainable economic growth. This indicates the dire need to investigate the relationship between electricity consumption and economic growth at sectoral levels. The results of an empirical investigation of the causal association between electricity consumption and economic growth by incorporating financial development in the production function may be helpful to policy makers in designing energy and growth policies for sustainable economic development, using financial development as an economic tool. The appropriate energy and economic policies can be recommended after a careful empirical analysis between economic growth and electricity consumption at the aggregate and sectoral levels in the case of Pakistan. To do so, this study investigates the association between electricity consumption, financial development, and economic growth by adding capital and labor as potential factors of domestic production at the sectoral and aggregate levels, covering the period of 1972-2014. We apply combined cointegration to examine the cointegration, and the robustness of the cointegration analysis is tested by using the bounds testing approach, accommodating the structural breaks in the series. The causal association between the variables is tested by employing the VECM Granger causality approach.

The results suggest the existence of a cointegration relationship at the aggregate and sectoral levels. At the aggregate level, electricity consumption plays a vital role in stimulating economic activity. Financial development is positively linked with economic growth. The relationship between capitalization and economic growth is positive. Labor increases domestic production and hence stimulates economic growth. At the sectoral level, electricity consumption stimulates growth in the agriculture, industry, and services sectors. Financial development boosts production in the agriculture, industry, and services sectors, which are contributory factors to economic growth. Capital is positively linked with growth in the agriculture and industrial sectors, but it decreases domestic production in the services sector. Labor not only contributes to agriculture sector growth but also adds to the growth of the industrial and service sectors. The causality analysis reveals bidirectional causality between electricity consumption and economic growth (aggregate and sectoral levels). The feedback effect exists between financial development and electricity consumption in the agriculture and services sectors. Financial development causes electricity consumption in the industrial sector (unidirectional causality also runs from financial development to economic growth). The relationship between financial development and economic growth is bidirectional in the agricultural and services sectors.

With respect to policy implications, we find that the positive effect of electricity consumption on economic growth indicates the importance of a consistent electricity supply for sustainable economic development. In such a situation, energy exploration policies should be encouraged over energy conservation or load-shedding policies. The adoption of energy conservation or load-shedding policies will impede domestic production at the aggregate and sectoral levels.[xvi]

A feedback effect exists between electricity consumption and agricultural growth. Agriculture consumes less electricity compared to other sectors of the economy (including the industry and services sectors). To ensure a consistent electricity supply to the agriculture sector, the government should adopt energy exploration policies, namely, electricity should be produced by wood, waste, biomass, and biofuel at the rural level. To achieve this goal, the State Bank of

Pakistan (SBP) should instruct agriculture development banks to provide loans to farmers for electricity generation using biomass energy sources. The bidirectional causality between financial development and electricity consumption reveals that both sectors are interdependent.

The feedback effect also exists between agriculture growth and financial development. This implies that the adoption of expansionary monetary policy boosts the agri-economy as well as enables farmers to generate energy from biomass, wood, and waste energy sources. This raises the demand for financial services and advances financial development. In this regard, micro-finance schemes should be introduced by the SBP for energy investment. The government should also import technology from France to generate electricity from cheese waste because Pakistan is the third largest milk producer in the world the financial sector can finance this project for electricity generation.

The feedback effect exists between industrial growth and electricity consumption, and a similar outcome exists for services sector growth and electricity consumption. This indicates the importance of electricity for both sectors, and adoption of energy (electricity) conservation policies may decrease their productivity. A consistent supply of electricity should be encouraged for sustainable growth of the industrial and service sectors. However, this may cause environmental degradation. Therefore, the financial sector should be encouraged to provide financial resources to firms for R&D activities. Firms need to import energy-efficient production technology to generate electricity at the local (firm) level (e.g., technology from Sweden to recycle solid waste into energy). The government should provide incentives (tax rebates) for the use of energy-efficient technology while enhancing domestic production and adopting the above-mentioned types of recycling technology.

At the aggregate level, economic growth, financial development, and electricity consumption are interdependent. For example, the feedback effect between electricity consumption and economic growth reveals the importance of energy exploration policies for long-run sustainable economic development. The bidirectional causality between financial development and economic growth (financial development and electricity consumption) indicates the importance of expansionary monetary policy at the macro level. Therefore, the financial sector plays a supporting role in the relationship between economic growth and electricity consumption. For a consistent supply of energy, financial sector can be used as a financial and economic tool. The Punjab government's recent support to energy sector investment by the banking sector is a noteworthy initiative, but more is required to manage the significant load-shedding problem.

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Notes

[i] The classification of electricity consumption in the agriculture, industrial, and services sectors helps to investigate the direction of causality between electricity consumption and economic growth at sectoral levels, and essential types of electricity consumption can be illustrated. Electricity consumption contributes to the growth in the agriculture, industrial, and services sectors, and in turn, growth in key sectors may also be linked with higher electricity demand. Higher electricity demand (consumption) in the industrial sector may be reflected by higher investment in machinery equipment, resulting in higher economic growth. Likewise, an increase in economic growth may raise firms' capacity to make

investments that increase the demand for electricity in the industrial sector. This leads to the conclusion that there may be bidirectional causality between both variables in the industrial sector. The relationship between the agriculture sector and agri-growth reveals that electricity consumption in agriculture stimulates agri-output, and in turn, an increase agri-growth will enhance demand for electricity. The same hypothesis can be drawn between electricity consumption in the services sector and growth in that sector in the country.

[ii] Existing studies apply traditional unit root tests such the Augmented Dickey–Fuller (ADF), Phillips–Perron (PP), Dickey–Fuller generalized least squares (DF-GLS), Kwiatkowski–Phillips–Schmidt–Shin (KPSS), and Ng–Perron tests in order to test the integrating properties of the variables. All developed and developing economies implement various economic, social, financial, trade, and economic reforms to stimulate economic activity, and hence, economic growth. The unit root problem may be the cause of all reforms. The occurrence of structural breaks in the series weakens the results provided by these traditional unit root tests owing to their weak explanatory power.

[iii] The contribution of the agriculture, industry, and services sectors to the gross domestic product (GDP) in 1971 was 35.52 %, 16.56 %, and 41.33 %, respectively, and increased to 21 %, 20.8 %, and 58.2 %, respectively in 2014.

[iv] The findings of this paper are expected to (a) increase the understanding of the interaction between energy (electricity) and economic growth variables, (b) resolve some contentious views fueling the ongoing debate on energy consumption, and (c) contribute to energy policy development, to address public concerns.

[v] Their results indicate that industrial output growth has a positive effect on energy consumption from fossil fuels, hydropower, natural gas, solar power, and waste, but coal consumption negatively affects industrial output growth.

[vi] They apply linear and non-linear causality tests, and find bidirectional causality between economic growth and electricity consumption at the aggregate level, and the same inference is noted for industrial output and electricity consumption.

[vii] The causality runs from energy to economic growth, and nuclear energy consumption causes economic growth. The unidirectional causality is found to

run from residential renewable energy consumption to economic growth, and economic growth causes industrial non-renewable energy consumption.

[viii] After confirming cointegration, the authors note that gas consumption is the Granger cause of industrial growth, and industrial output causes electricity consumption, but a neutral effect is confirmed between coal consumption and industrial productivity.

[ix] See Sadorsky[24,25] for more details.

[x] These countries are Pakistan, Bangladesh, India, Sri Lanka, Indonesia, Malaysia, Philippines, Singapore, Thailand, China, Japan, and South Korea.

[xi] Oil consumption and natural gas consumption add to economic growth, but electricity consumption and interest rate impede it. In the agriculture sector, oil consumption, natural gas consumption, and the availability of credit have positive effects on economic growth, but electricity consumption reduces real agriculture output.

[xii] The association between electricity consumption and economic growth by including financial development, capital, and labor is shown by equation-2. Equation-2 indicates how the long-run relationship between the variables may be expressed. The short-run dynamics indicate that any changes in electricity consumption, financial development, capital, and labor in the previous period contain suitable information to predict output in the current period, keeping other things constant[41]. This leads us to apply multivariate cointegration and causality approaches for our empirical analysis.

[xiii] We have converted data into real and per capita terms by dividing the series on consumer price index and total population before using them for the empirical analysis.

[xiv] The lag order for the Bayer–Hanck combined cointegration test is based on the Akaike information criterion (AIC).

[xv] We refer to Narayan[117] for the critical bounds.

[xvi] Shahbaz[91] estimated the sectoral cost of load shedding. The findings report that economic loss due to the electricity crisis was PRS 27.11 billion, PRS 104.49, and PRS 110.62 billion for the agriculture sector, industrial sector, and services sector, respectively in 2013. This loss is estimated to grow by 234.75%,

40.50%, and 113.75% in the agriculture, industrial, and services sector, respectively by 2050 if the electricity crisis continues.