North American Academic Research

Journal homepage: http://twasp.info/journal/home

Research

Agricultural and Manufacturing Sector Determinants of Electricity Consumption, Price, and Real GDP from Pakistan

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***Accepted**: 30 December, 2019; **Online**: 10 January, 2020*

***DOI** : https://doi.org/10.5281/zenodo.3604943*

Abstract : For the upcoming years, Pakistan's electricity consumption forecasts estimated to exceed electricity generation capacities. In this study we explore the causal relationship between electricity consumption (EC), electricity price (EP), and real GDP at the various sectors, and general level from the period 1970 – 2018 in Pakistan, by using Johansen Co-integration test and Vector Error Correction Model (VECM). The following determinants selected, such as EC, EP, GDP, other electricity consumption (OEC), and urbanization population growth (UPG) from agricultural and manufacturing sectors. The outcomes indicate that there is a constant long-run relationship exist in agricultural and manufacturing sector. While short-run causality also supports the hypothesis in both sectors. These results support the hypothesis and indicate that electricity consumption, price, and economic growth in Pakistan spurs, but not the other way around. Moreover, the research findings could be beneficial for policymakers, as well as electricity management to strengthen the long-lasting economic policies.

Keywords: *Electricity determinants, Economic growth, Urbanization, VECM, Pakistan*

1. Introduction

Historically, as stated, in human history, the trend in energy demand is constantly rising. However, this trend has been vigorously rising worldwide from the last couple of decades; even life without electricity becomes extremely difficult. The Asia region comprises of more or less 4.5 billion out of 7.5 billion populations, which has been estimated as emerging in the world nexus. More precisely, Pakistan is under the scope of Asian countries it holds an approximate 0.21 billion of the world's 6th largest community (Hali and Kamran 2017). Therefore, an increase in demand for electricity cannot be deniable. Addressing this growing issue is utmost important. While the population has been overgrowing over the previous couple of decades, this is highly concerning for the country's think tankers and officials to determine the likely consequences, that can drag all industries into the worst economic chaos, where the economy is already struggling. Electricity is indeed a key element for the viable economic stability of the country. Pakistan's energy demand and supply are also addressed, and several measures need to be taken to resolve a serious crisis that can directly or indirectly influence every main economic sector.

Electricity demand is rapidly growing throughout the world, and countries have become depending on it, that in the coming few years could be worrying. However, energy plays a major role in optimizing the mechanism of development, which is an important part of the financial cycle that is extremely concerned around the world. Industrial, commercial and agricultural sectors are the dominant sectors of every country that make a significant contribution to economic development.

Because of less investment in energy generation and conservation, the Western energy crisis started in 2000. The consequences felt throughout the world during the 2008 economic collapse as oil prices hit the highest level in world history. The energy crisis started to end in the last month of 2008 as economic indicators were in global recession, then oil prices dropped from $147 per barrel to $32 per barrel (Worldatlas 2018). On the other hand, because of less energy use, developing nations are anxious and conservation could be a barrier to economic development in the future.

Subsequently, the question of the relationship between economic growth and consumption of electricity became a popular subject of research in economics and environmental sciences even though it was not a part of the traditional system. Moreover, the benefits of extensive use of energy established consent to integrate into national accounts due to economic considerations. This course of action, however, is not yet compelling. Numerous studies have shed light on this subject over the past few decades, but there is still a void to draw a more definitive conclusion — many studies have concentrated narrowly on the specific aspects.

The first claim was unidirectional causality based on power consumption and economic growth, defining the hypothesis of growth. Also supported the next assumption, which identified conclusion on conservation. Bi-directional causality between power consumption and economic growth, that is regarded as feedback consumption, was explored at this time.

The last denied the existence of the power consumption financial growth relationship, which accepted the presumption of neutrality (Jamil and Ahmad 2011). Electricity is the dynamic aspect of economic activity that acts as a catalyst for any country's development in all service sectors. Sadly, Pakistan's energy policy has failed over the past several decades and the energy crisis remains a huge obstacle to economic development. There are many other factors that cause massive line losses that affect the electricity consumption, like weather, improper use of electricity, undocumented connections, and overuse of domestic electrical appliances. There is also a lack of administrative capability, poor governance, corruption and political conflict over large scale-energy projects (Hussain, Rahman, and Alam 2015).

Previous studies have suggested logical conclusions in different geographical regions, for example, (Faisal, Tursoy, and Ercantan 2018) examined the causality direction of electricity consumption and GDP. The empirical research suggests two conceptual views. Is economic growth causing increased demand for consumption of electricity? Isn't economic growth the source of rising demand? Bi-directional causality has been running and confirming the argument of the paper.

The further analysis presented the first empirical evidence of the long-term association between electricity consumption and GDP, that was essential for policymakers to implement (Ikegami and Wang 2016). Some other research found out that, although this rise does not remain unchanged, the labor market expanded through economic prosperity. Here, with other factors like capital stock and electricity, similar outcome found. As noted in this analysis, multiple factors influence in the energy boost in contrast to capital stock. It temporarily stimulates the exogenous shocks to labor and capital stock, as well — immense skilled labor required for the dynamic financial spark (Zeshan and Ahmed 2013).

Electricity is now extensively recognized as an important determining factor in the growth of economic statistics, which is considered to be a growth driver in the nationally and internationally. The consistency needed to develop this method at this time. While developing countries are especially concerned regarding current demand, supply shortages and conservation, and also concentrate on effective use that improves the country's economic progress (Khan and Qayyum 2009). However, the credibility as a positive contributor to power generation in the corporate world will be appreciable. The estimated variables illustrate rapidly growing energy demand trend and real GDP shown in **Fig. 1, 2,** and **3**.

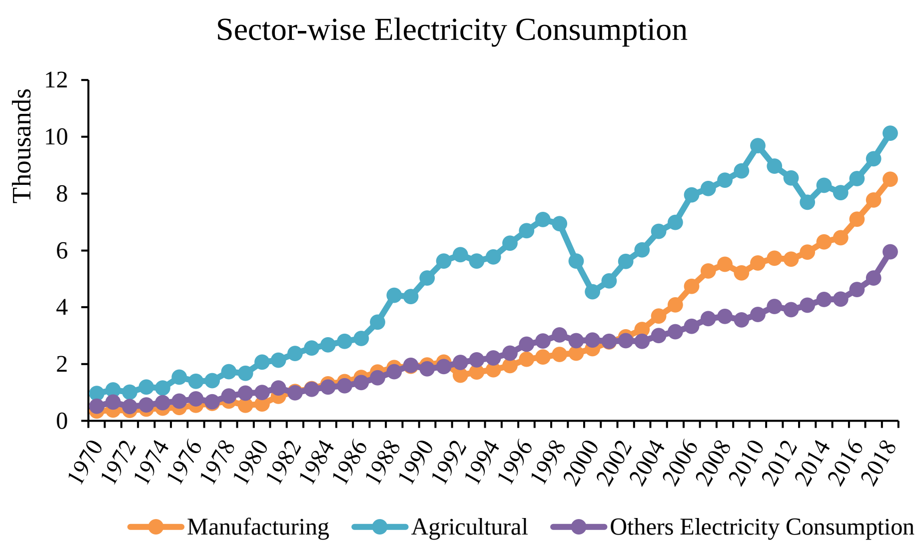

Fig. 1. Sector-wise yearly electricity consumption

2018).

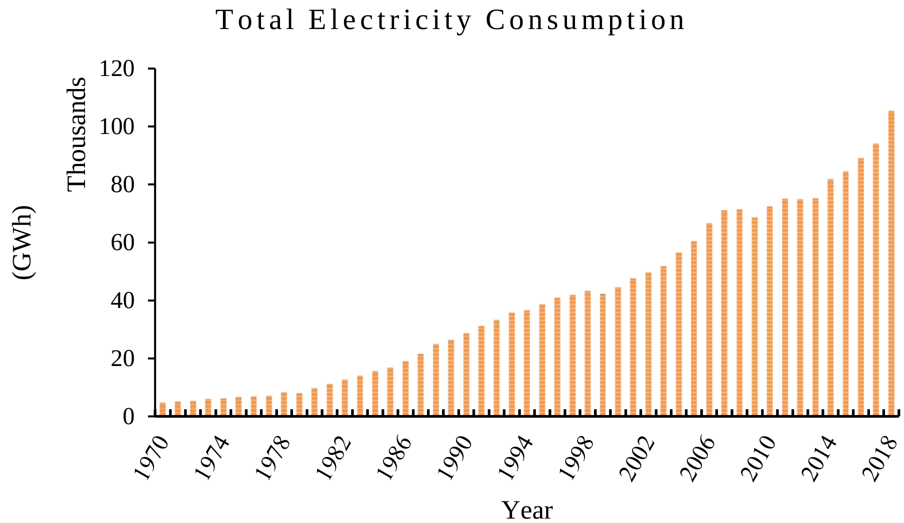

Fig. 2. Total power consumption year-wise

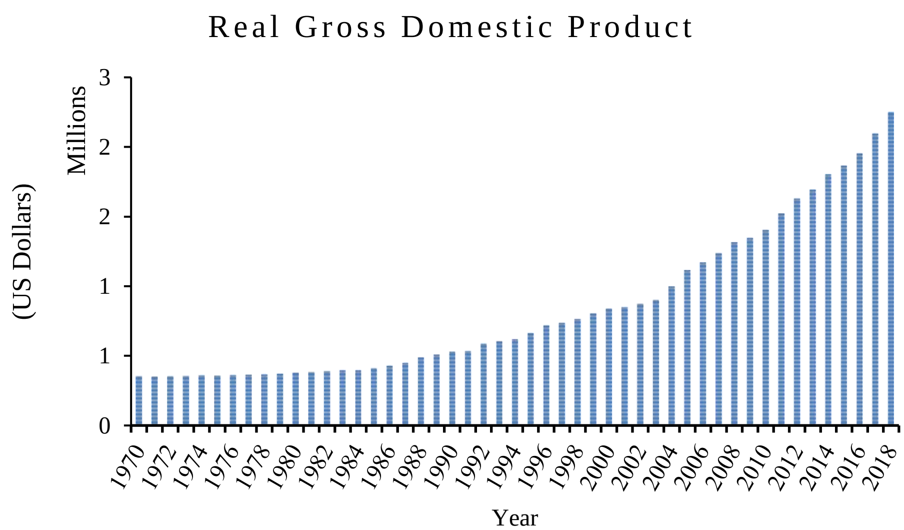

Fig. 3. Real Gross Domestic Product (GDP) Pakistan

In the current energy shortage, the edge of 6000 MW has been reached and the country's urban and rural areas are suffering load-shedding of 10 – 14 hrs, overall. Presently, electricity demands surpass 25000 MW. In Pakistan, nevertheless, the generation is just 18900 MW (The-Nation 2018).

The present study objectives to empirically investigate the EC, EP, and economic growth relationship in Pakistan from 1970 – 2018. This research explores the numerous factors which are important in the case of Pakistan that supports policymakers for making decisions regarding viable policy. There are many interrelated types of literature reviewed in this respect as mentioned in references (Khan and Qayyum 2009; Aqeel 2001; Javid and Qayyum 2014; Shahbaz and Feridun 2012; Jamil and Ahmad 2010). We have used yearly data on EC, EP, and RGDP to find short-run and long-run causality in agricultural, and manufacturing sectors. Our research has many decent implications both academically and practically. Initially, to the best our knowledge and evidence, our research, amongst the earlier studies for examining EC, EP, and real GDP, is one of the erratic studies that have concentrating on these particular aspects.

2. Brief Literature Review

In the study of Saif Kayed and colleagues, they distinguished various economies of countries such as developed, underdeveloped or developing, transition economies. They also highlighted the factors involved in economic change with electricity management (Al-bajjali and Yacoub 2018).

Electricity consumption and financial growth relationship explored the first time by (Kraft and Kraft 1978); they researched in the USA from 1947 – 1974. In their findings, they conclude the causality run between power consumption to economic growth. Furthermore, to expend this area of research, numerous studies published in previous decades to reach out more concrete conclusion, which revealed that power consumption and financial development are associated with each other. The subject of power demand for developing and developed economies being most encouraging for the researcher. The production function is highly dependent on energy as well as it is accelerating the growing electricity consumption which works as fuel for the economic engine. As evidence from Pakistan shown by (Aqeel 2001), that financial development affects by electricity consumption, also interpret that bi-directional causality in petroleum goods and evidence exists that there is no relationship found with the natural gas.

However, (Jumbe 2004) shown in the study at Malawi used data from 1970 – 1999, to find out the co-integration and causality among energy consumption, whole GDP, agricultural, and non-agricultural GDP. The outcome revealed that co-integration exists between overall GDP and non-agricultural, while no evidence found against agricultural. The analytical approach error correction model and Granger causality results have shown bi-directional causality between electricity consumption to GDP and unidirectional causality runs non-agricultural GDP to energy consumption. As in the case of Indonesia, the study targeted the association between real GDP growth and electricity generation by (Yoo and Kim 2006) and concluded that unidirectional causality exists between financial development and electricity generation deprive of any feedback effects. The interpretation of research outcome described as follows when the countries going towards modern economy electricity generation and consumption parallel grow in all sectors. For instance, households consume more electricity day by day due to the higher disposable income. Unlike, commercial, industrial are sectors where energy consumed at high level that reflect in economic progress.

(Zachariadis and Pashourtidou 2006) contributed in the same research area used annual data from 1960 – 2004 in Cyprus, and empirically examined electricity consumption by commercial and residential usages; these are highly contributing sectors in terms of consistent, speedy growth of energy on the island. Their dynamic analysis revealed electricity usage, income, price, and weather relationship. The analytical tools and techniques used in this time series data as follows; unit root, Johansen co-integration, Granger causality, (VECM), and impulse response. The result shows positive long-term effects by income and price on electricity consumption and similar elasticity found in other countries. While variability in weather seems to be an utmost important cause for short-tern fluctuation in electricity usage, however, income and price are not significant for the short term. As per Granger causality test electricity price could be treated exogenous, income, and price determined granger cause of power consumption, and bi-directional causality found between household electricity, and private income. As a whole, the outcome of the manufacturing sector found minimum elastic changes among weather, income, price, and previous shock. However, later, it inclines return to equilibrium much quicker than the household zone.

(Yuan et al. 2007) analyzed the co-integration method for the examination of a causal association between power consumption and RGDP, used data from 1978 – 2004 in China. The output about real GDP and power consumption shows co-integration and unidirectional causality from response variable to control variable. However, in contrast, (Odhiambo 2009) also pointed out that power consumption and financial progress observed bi-directional causality for the case in South Africa. Also, the research study discovered a distinctive unidirectional causality by employ for economic development. According to (Yalta 2010) findings the power consumption and GDP connection is a vulnerable economy situation. Monitoring of oil prices, and real exchange rate, consequences reflect no causal relationship between electricity usage and GDP. Their results were robust by the selected period as well as the numeral of lags cast-off in model requirement.

On the other hand, in Poland (Gurgul and Lach 2012) studied the affiliation of EC and GDP. The conclusion comparatively more strong backing to claim about the feedback by aggregate power consumption, GDP and employment in dual periods. This evidence could be inferred that the configuration of causal dependencies among variables was reasonably robust, and it was not utterly interrupted in the crisis of 2008. Likewise, another study empirically identified that co-integration between chosen variables reflect long-run equilibrium associated in all cases. The outcomes indicated a unidirectional causal relationship from power consumption to financial development, which suggests energy is a restraining feature to monetary progress. Henceforward, shocks to energy supply would have a contrary effect on fiscal progress (Yasmin, Muhammad, and Awan 2012).

Also, (Shahbaz and Hooi 2012) re-examined the dynamic association between power consumption and financial development for Pakistan. The study empirically revealed that energy consumers, economic growth, capital, and labor found long-run equilibrium relations. Besides that, the analysis explored positive and significant relationships between capital and labor on economic development. Moreover, bi-directional causality exists between EC and EG for short and long-run periods. Also, capital and economic growth have bi-directional causal relationships.

Furthermore, Malaysia (Foon and Shahbaz 2013) revealed that electrical energy consumption and progression are not co-integrated. Though, the standard Granger's test and MWALD test recommend that power consumption and economic progress are causes towards each other. Additionally, (Dhungel 2014) confirmed that a long-run relationship indicated by Johansen co-integration. Likewise, the OLS estimation coefficient found statistically positive at approximate level expressed by a 1% significant variation in foreign aid, GDP being changed electricity usage by 0.0027 and 0.0227, respectively. ECM model indicates long-run, and short-run equilibrium exists.

In the recent past, (Zhang and Zhou 2017) explored an inclusive indication of power consumption and economic progress association. Their findings based on 38 years from 1978 – 2016. The study focused on some critical problems. The conclusion summary overview encourages the evidence found in terms of positive relationships among variables. In Ghana, (Ameyaw et al. 2017) inspected that the causality direction within power consumption to GDP from 1970 – 2014, which construct on a Cobb-Douglas model. The research revealed the long-run equilibrium co-integrated relation found in capital, labor, and EC. Conversely, VECM indicates the long run conjunction along the fastest speed of error-correction while the Granger causality is running between GDP to power consumption.

Lately, (Al-bajjali and Yacoub 2018) conducted a study in Jordan, from 1986 – 2015, the research objective to propose various variables to recognize energy consumption. In order to achieve the multivariate goal, six explanatory variables used, such as urbanization, population, electricity prices, GDP, the structure economy, and water. The conclusion reveals that industry, urbanization, GDP, and cumulative water points out energy consumption in a positive direction. An additional study conducted in Belgium by (Faisal, Tursoy, and Ercantan 2018) studied the relationship between GDP and electricity power, the sample based on a couple of decades from 1960 – 2012. The research applied Auto-Regressive Distributed Lag (ARDL) and Toda-Yamamoto (T-Y) method to find the causality. The outcomes indicated that the long-run association between power consumption with GDP.

Additionally, GDP and EC positively significant in terms of long and short run. The convergence rate of long-run energy consumption is 0.17, which endorsed the stability of the system by using the T-Y method technique of causality. The research found a unidirectional relation between EC to GDP, which proved the legitimacy of preserve assumptions in Belgium. **Table 1** shows the detailed summary of past research

Table 1 Assessment of causality effects in several studies

Authors	Determinants	Methodology	Country	Period	Causality
(Y. W. Ã 2006)	GDP, EC	Toda Yamamoto	Egypt	1971 - 2001	EC → GDP
(C. F. T. Ã 2008)	EC, EG	ARDL, ECM	Malaysia	1972 - 2003	EC → GDP
(Adom 2011)	EC-GDP	Granger Causality	Ghana	1971 - 2008	EG → EC
(Wang et al. 2019)	EC, EP, URB	Granger Causality	China	1980 - 2015	GDP ↔ EC

(Gurgul and Lach 2012)	EC, GDP	ARDL, VECM	Poland	2000 - 2009	EC ↔ EG
(Nazlioglu, Kayhan, and Adiguzel 2010)	EC, GDP	ARDL, VECM	Turkey	1967 - 2007	EC ↔ EG
(Acaravci, Erdogan, and Akalin 2015)	EC, GDP	Granger Causality	Turkey	1974 - 2013	EC → GDP
(Morimoto and Hope 2004)	GDP, EP	Granger Causality	Sri Lanka	1960 - 1998	EC → GDP
(Hooi and Smyth 2010)	GDP, EG, EP	Granger Causality	Malaysia	1970 - 2008	EC → EG
(Faisal, Tursoy, and Ercantan 2018)	EC, GDP	Toda Yamamoto	Russia	1990 – 2011	EC ↔ GDP

Note: → represents unidirectional, ↔ bidirectional

3. Dataset collection and methodology

We have used time series secondary data in this study based on yearly observation, covering six decades almost from the duration 1970 – 2018 shown in **Table 2**. The electricity will measure in Gigawatt hour (GWh). Since electricity has been a public enterprise in Pakistan, the EP is cross-subsidizing in all sectors instead of determined by the market. We are using the average price of electricity in all categories — overall real GDP of manufacturing, and agricultural denoted as GDP.

Table 2 Data and measurement

Variables	**Data Source**	**Scale Unit**
Agricultural EC	(PES 2018)	(GWh)
Manufacturing EC	(PES 2018)	(GWh)
Other Electricity Consumption	(PES 2018)	(GWh)
Electricity Prices	(NTDC 2018)	Millions

Urban Population Growth	(WDI 2018)	Annual (%)
Real Gross Domestic Product	(WDI 2018)	$Millions

3.1. Methodology

The study examines the relationship between EC, EP, and GDP at the two main sectors of Pakistan. We have used quantitative data with a descriptive approach, also applied econometric methods, such as (Johansen co-integration, VECM, and Granger causality test), which commonly used in multivariate time series analysis.

3.1.1. Unit root test

First, the stationarity will be tested for all variables, and two subsequent tests are well known for that (i) Augmented Dickey-Fuller (ADF) (ii) Phillips – Perron (PP) tests to detect integration in all series stated in equation (1):

$$\Delta yt = \beta_0 + \delta Y_{t-1} + \gamma_1 \Delta y_{t-1} + \gamma_2 \Delta y_{t-2} + \dots\dots\dots\dots \gamma_p \Delta y_{t-p} + u_t \qquad (1)$$

Where, y_t denotes a series and u_t represents (iid) error terms (Dickey and Fuller 1979; Phillips and Perron 1988). Appropriate lags of Δy_t are incorporated for the whiten the errors. The lag length is selected according to Schwarz Bayesian criterion (SBC), afterward testing for 1st and higher order serial correlation in residuals. For the H_0 null hypothesis test in equation (1) is 'd,' which = 0, against the one-tailed, and alternative which is negative. The stationarity of y_t would not be rejected, If δ result outcomes significantly negative. Modeling associations among non-stationary features necessarily need their differencing to make stationarity.

For several years, due to differences, most of the long-run economic relationship has been lost, while maintaining the long-run, relation massive data needed at the level. In the meantime, selected variables avoid spurious regression. Long-run equilibrium relationship exists among the non-stationary time series results, according to recommendations of economic theorists. If variables are $I(1)$, so co-integration method will be used for the long-run relation. Hence, unit root is the primary step to move into co-integration model.

3.1.2. Johansen Co-integration test

Therefore, the Johansen co-integration test will be used on the next step after all the series integrated in the same order. For that, maximum likelihood approach for co-integration test would be applied, which is based on trace statistics as well as maximum eigenvalue statistics, while Granger causality existence confirms by the co-integration test.

3.1.3. Vector error correction model (VECM)

The direction of causality is found in the co-integrated series through the use of VECM on the third step. In condition, variables are co-integrated at $I(1)$. Therefore, Granger represented a theorem affirms that there is an error correction information generating apparatus concluded the symmetry error u_t. The past period in the error correction model denoted by u_{t-1}. Likewise, it summarizes the corrections to the long-run equilibrium shown in equations 2, 3, and 4:

$$\Delta EC = \alpha_1 + \sum_{i-1}^{l} \beta_{1i} \Delta\, EC_{t-i} + \sum_{i=1}^{m} \gamma_{1i}\, \Delta EP_{t-1} + \sum_{i=1}^{n} \delta_{1i}\, \Delta GDP_{t-1} + \sum_{i=1}^{n} \zeta_{1i}\, \Delta UPG_{t-1} + \sum_{i=1}^{n} \psi_{1i}\, \Delta OEC_{t-1} + \varphi_1 ECT_{r,t-1} + u_{1t} \qquad (2)$$

$$\Delta EP = \alpha_2 + \sum_{i-1}^{l} \beta_{2i} \Delta\, EC_{t-i} + \sum_{i=1}^{m} \gamma_{2i}\, \Delta EP_{t-1} + \sum_{i=1}^{n} \delta_{2i}\, \Delta GDP_{t-1} + \sum_{i=1}^{n} \zeta_{2i}\, \Delta UPG_{t-1} + \sum_{i=1}^{n} \psi_{2i}\, \Delta OEC_{t-1} + \varphi_2 ECT_{r,t-1} + u_{2t} \qquad (3)$$

$$\Delta GDP = \alpha_3 + \sum_{i-1}^{l} \beta_{3i} \Delta\, EC_{t-i} + \sum_{i=1}^{m} \gamma_{3i}\, \Delta EP_{t-1} + \sum_{i=1}^{n} \delta_{3i}\, \Delta GDP_{t-1} + \sum_{i=1}^{n} \zeta_{3i}\, \Delta UPG_{t-1} + \sum_{i=1}^{n} \psi_{3i}\, \Delta OEC_{t-1} + \varphi_3 ECT_{r,t-1} + u_{3t} \qquad (4)$$

Where $EC, EP, GDP, UPG\ and\ OEC$ represents electricity consumption, electricity price, real GDP, urbanization population growth, and other electricity consumption. Correspondingly, 'α' is the intercept 'n' is the number of lags, 'Δ' is the 1st difference, the joint consequence of lags $\beta_{1i}, \gamma_{1i}, \delta_{1i}, \zeta_{1i}, \psi_{1i}$ in equation (2), $\beta_{2i}, \gamma_{2i}, \delta_{2i}, \zeta_{2i}, \psi_{2i}$ in equation (3), and $\beta_{3i}, \gamma_{3i}, \delta_{3i}, \zeta_{3i}, \psi_{3i}$

in equation (4), while $u_{i,t}$ For$(i = 1, 2, 3)$ are residuals, and the error correction terms indicated by $ECT_{r,t-1}$ and $'\varphi'$ is the adjustment of model speed towards equilibrium. For example, scale and the numerical significance of the one-period lag $ECT_{r,t-1}$ coefficient determines how quick the disequilibrium in $EC, EP\ and\ GDP$ are corrected in order to return to the equilibrium. The VECM equations (2), (3), and (4) specifies from EC to OEC, EP to OEC, and GDP to OEC, respectively.

All the variables are in the natural logarithm — the deviance by long-run equilibrium slowly adjusted through the short-run series of adjustments. The statistical meaning of ECT is the degree of range in which the left-hand sided variable returns in a single equation distinctly to the short-run and long-run equilibrium in feedback of causal shocks. Hence, error correction model via ECT brings in another channel for recognition of Granger causality.

The causality from $EC, EP, GDP, UPG\ and\ OEC$ could be tested from equation (2). Causation from $EP\ to\ OEC$ and from $GDP\ to\ OEC$ could be tested similarly from equation (3), and (4), respectively. Even though co-integration specifies the existence of causality, though the direction of causality between the variables are specified by VECM.

3.1.4 Granger causality test

The Granger causality test explains statistically, whether one stochastic process is valuable for the approximating alternative, primarily suggested by (Granger 1969). Normally, regressions reflect "mere" correlations, but Clive Granger claimed that causality in economics could be tested by determining the ability to forecast the future values of a time series by using previous values of other time series. The Granger causation test could be stated among variables by error correction exemplification previously discussed as follows:

(i) The joint consequence of lags β_{1i} to ψ_{1i} in equation (2), β_{2i} or ψ_{2i} equation (3), and β_{3i} or ψ_{3i} in equation (4) specifies causality from $EC\ to\ OEC, EP\ to\ OEC\ and\ GDP\ to\ OEC$, respectively and u is residual. Finally, the chi-square measurement for joint test on coefficients of lagged variables is symbolic for the multiplier effect for short-run causation run from targeted variables to explanatory variables. For example, any uncertainty in the combined test of coefficients of all lags shows that γ_1 considerably arrives in the equation of EC, which recommends the EP cause EC in the short-run.

(ii) (Soytas and Sari 2003) expressed, the test implication of φ_i (coefficient of ECT) directs that the long-run equilibrium association is a straight dynamic explained variable. It might also be called a weak exogenity test.

For the detection of Granger causality, it could be checked by dual sources of causation that are jointly important. It could be done by the significant joint test of coefficients, as mentioned in above paragraphs.

The first step detected from the importance of the coefficient of ECT, and extended as long-run causation. While insignificance of this coefficient involves weak exogenity for the variables that exist at left-hand adjacent in the equations. The significance articulated in the long-run equilibrium relation is running among the variables at left-hand in coefficients of ECT.

4. Results and discussions

4.1. Unit root test

Firstly, the stationary test among all variables to be done, that is necessary to prevent spurious regression. The H_0 considered as non-stationary series and H_1 for stationary. There are several tests accessible among them, and two are quite established tests using ADF and PP immensely. Both tests have applied at the level, and also first difference that shows similar results for all variables calculated the outcome in **Table 3** at the level of 1% and 5% considered significant. However, the H_0 of non-stationarity has been rejected in all chosen series at their level and first difference, it could be determined that EC, $EP, GDP, UPG, and\ OEC$ are integrated at $I(1)$.

Henceforward, the first difference both tests confirmed the stationarity in all variables, and it is the essential requirement of co-integration.

Table 3 Outcomes of the unit root test

Variables	Philips–Perron (PP)		ADF		Order of Integration
	Levels	First difference	Levels	First difference	
Agricultural					
EC	-1.85	-6.85*	-1.85	-6.85*	*I*(1)

EP	-1.30	-8.34*	-1.35	-7.35*	*I*(1)
GDP	-0.25	-8.88*	-0.28	-8.65*	*I*(1)
UPG	0.12	-2.99*	-0.50	-2.99*	*I*(1)
OEC	-1.15	-9.97*	-1.02	-10.07*	*I*(1)
Manufacturing					
EC	-1.04	-6.06*	-1.04	-6.09*	*I*(1)
EP	-1.39	-5.51*	-1.46	5.51*	*I*(1)
GDP	-0.87	-4.26*	-0.77	-4.18*	*I*(1)
UPG	0.12	-2.99*	-0.50	-2.99*	*I*(1)
OEC	-1.15	-9.97*	-1.02	-10.07*	*I*(1)

*The asterisk indicates significance at 5% level, ** asterisk indicates significance at the 10% level.

4.2. Johansen co-integration test

After completing the first condition, we move to the next part to find out a long-run relationship exists or not among the variables. Therefore, (Johansen 1988; Søren Johansen 1990) maximum likelihood approach employed to find the co-integration, which comprises of the two following estimations:

$$1 - trace\ (\lambda - trace), 2 - maximum\ eigenvalue\ (\lambda - max)\ statistics$$

The H_0 is rejected against the H_1 at 5% level. Hence, it is confirmed that there is a long-run relationship exists in all variables. The illustration of unrestricted co-integration results displayed in **Table 4**.

Table 4 Johansen Co-integration test

Sectors	Hypothesized no of cointegrating	λ_{trace} Statistics	λ_{max} Eigen Statistics	*EC*	*EP*	*GDP*	*UPG*	*OEC*
Agricultural	0	96.53	46.65	1	-0.24	90.84	-39.65	106.64
		(0.0001)*	(0.0009)*		(1.08)	(15.61)	(9.24)	(14.42)
	r ≤ 1	49.88	25.51					
	r ≤ 2	24.36	15.43					

Manufacturing	0	86.02	34.37	1	-0.91	1.73	1.37	6.52
		(0.001)*	(0.004)*		(0.39)	(1.18)	(0.86)	(1.31)
	r ≤ 1	51.64	24.37					
	r ≤ 2	27.27	17.82					

Notes: Numbers in the parentheses are p-values, r: Indicates the number of hypothesis co-integration relationship, * the asterisk indicates significance at 5% level. the figures in () are t-values, critical values are taken from Mackinnon–Haug–Michelis (1999).

4.3. Vector error correction model (VECM)

As with the sequence we will carry out the VECM analysis as described in equations (2) – (4) earlier, through which we can identify the direction of long-term causality relationships of each variable, either exogenous or endogenous. The result of the VECM exhibited in **Table 5**. Error correction term relies on the previous period deviation from long-run equilibrium influences the short-run dynamics of the explanatory variables. Consequently, the coefficient of ECT, φ , is speed of adjustment; it dealings the speed at which explained variables return to equilibrium after a change in the explanatory variable (Engle, Granger, and Mar 1987).

In agricultural sector EC has a negative coefficient -0.06 and significant at 5%. It shows the return back speed towards equilibrium. If EP increase by 1% EC increase by 0.01, and 1% change in GDP, increases EC by 0.18 on average. If UPG increases by 1%, EC increases by 0.35. While OEC increase by 1% EC increase 0.27. EP coefficient is -0.50 negative which is not supporting. While, EC increase by 1% EP decrease -0.37, GDP increase by 1% EP increase 2.69 while, 1% change in UPG affects EP by 6.40 upwards and OEC increase by 1%, then EP decreases by 0.65. GDP coefficient is -0.01, which is significant at a 5% level. Further, EP increases by 1% GDP increase 0.006, EC increases by 1%, and GDP increases by 0.05. If UPG Increase by 1% GDP increase by 0.04 and OEC increase by 1% GDP decreased by -0.08. As a whole, in the case of agriculture, there is a long-run causality exists.

As manufacturing sector output shows, EC -1.36 negative also shows insignificant long-run relationships at 1% level. Where 1% change in EP increasing by 0.03 to EC. 1% increase by GDP decrease 0.01 in EC, as well 1% UPG increase effects of 0.80 upwards in EC. If 1% of OEC increases 0.64 increase in EC. The EP shows coefficient -0.43 and positively significant at 5%. If EC change by 1%, EP decrease by 0.05, and GDP increased by 1% EP increase by 0.07. If UPG changes by 1%, EP decreases by 0.03. If a 1% increase in OEC will increase in EP by 0.10. Whereas GDP, coefficient -0.18 significant by 5%. 1% change in EC effects GDP by 0.27, as well as 1% change in EP increase GDP by 0.17. Also, a 1% change in UPG increase GDP by 2.11, and 1% increase in OEC change the GDP by -0.15. Hence, we can conclude manufacturing sector that there is a long-run causality running.

Table 5 Vector error correction model

Sector	Long-run effects						ECT (t-stats)
	Δ*EC* Coefficient	Standard Error	Δ*EP* Coefficient	Standard Error	ΔGDP Coefficient	Standard Error	
Agricultural							
EC	1	-	-0.37	0.16	0.05	-1.64	(-2.36)**
EP	0.01	0.07	1	-	0.006	0.02	(-3.05)*
GDP	0.18	5.01	2.69	-0.30	1	-	(-2.19)*
UPG	0.35	5.69	-6.40	0.26	0.04	-0.43	
OEC	0.27	1.95	-0.65	-0.16	-0.08	-1.30	
Manufacturing							
EC	1	-	-0.05	-0.26	0.27	-0.07	(-3.90)**
EP	0.03	0.06	1	-	0.17	0.58	(-3.44)*
GDP	-0.01	0.03	0.07	0.32	1	-	(-2.03)*
UPG	0.80	1.23	-0.03	-0.25	2.11	0.92	
OEC	0.64	0.07	0.10	-0.04	-0.15	-0.04	

Note: ECT denotes error correction term

4.4. Granger Causality Wald Tests

The agricultural output from the short-term impact by GDP to EC while UPG effects to EC, EP and GDP shown in **Table 6**. Herein, manufacturing sector OEC to EC and UPG to EC, GDP to EP, EP to OEC, and GDP to UPG causality found at a 5% significant level.

Table 6 Granger causality Wald test

Sectors	Explained Variable	Granger Causality Wald Tests		df	Prob.
		Explanatory Variable	Chi-sq (X^2)		
Agricultural					
	EC	*GDP*	4.37	1	(0.0188)*
	EC	*UPG*	5.69	1	(0.0035)*
	EP	*UPG*	3.71	1	(0.0327)*
	GDP	*UPG*	11.13	1	(0.0001)*
Manufacturing					
	EC	*OEC*	3.29	1	(0.0468)*
	EC	*UPG*	7.15	1	(0.0021)*
	EP	*GDP*	3.41	1	(0.0421)*
	OEC	*EP*	6.16	1	(0.0045)*
	UPG	*GDP*	6.73	1	(0.0029)*

Notes: Number in the parentheses is p-value. *The asterisk indicates significance at 5% level; **Double asterisk indicates significance at 1% level.

4.5. Diagnostic tests

Finally, the model requires to prove the stability and its strength. The diagnostic test comprises of the various tests for the residuals such as serial correlation, heteroscedasticity, normality and stability tests shows model is fit and useful for analysis because there is no serial correlation, heteroscedasticity, and the residuals are normally distributed around the mean shown in **Table** 7.

Table 7 Diagnostic Test

Sectors	Agricultural		Manufacturing	
	F-Statistics	*Prob. Chi-Square*	*Prob. F*	*Prob. Chi-Square*
LM Test	0.75	0.52	0.32	0.11

Heteroscedasticity Test	0.76	0.62	0.66	0.58
Jarque-Bera	2.91	0.23	2.06	0.35

4.6. Stability test (CUSUM)

CUSUM test is performed to check the strength of the model's factors. The stability tests, according to the concerned model outcome, reflected stability at a 5% level of significance. Therefore, H_0 for instability has been rejected, as the blue residuals strokes situated inside the standard deviation (SD) lines shown in **Fig. 4**.

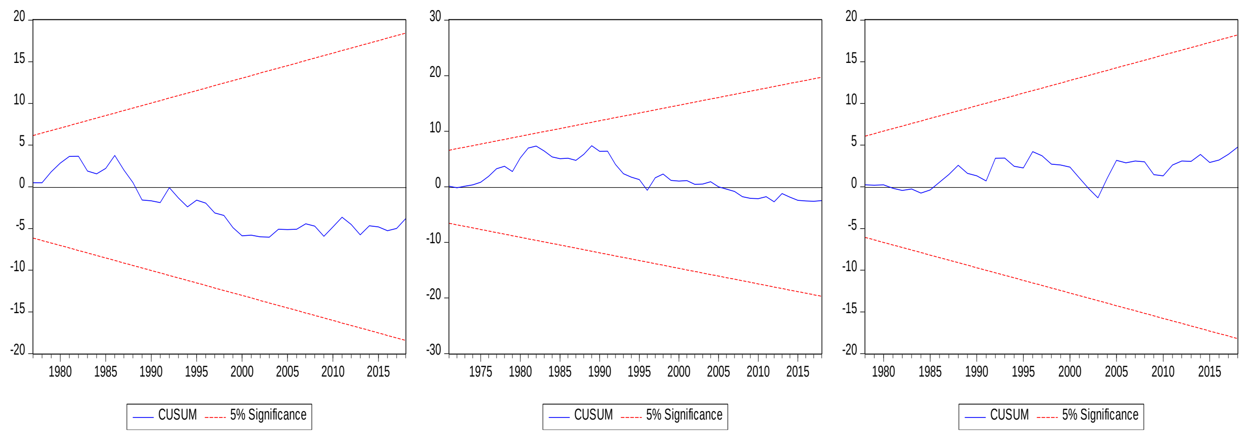

Fig. 4. Cusum stability test

5. Conclusion and policy inferences

5.1. Conclusion

The study empirically investigates the long-run and short run relationship between electricity consumption, price, and economic growth in Pakistan using the VECM, and Granger causality test method for the period 1970 – 2018. As per co-integration, VECM, and Granger causality outcomes, there is a stable long-run relationship exist between agricultural and manufacturing sector. The agricultural output for the short-term impact by GDP to EC while UPG effects to EC, EP and GDP. However, manufacturing sector OEC to EC and UPG to EC, GDP to EP, EP to OEC, and GDP to UPG causality found at a 5% significant level. These results support the hypothesis and indicate that electricity consumption, price, and economic growth in Pakistan spurs, but not the other way round.

5.2. Policy inferences and recommendation

There are numerous energy management measures endeavored to enhance generation reduce electricity consumption and overcome misuse in Pakistan may not have a negative impact on GDP. However, usage of electronic appliances, illegitimate electricity connections miserably enhancing the waste of energy in all sectors. Additionally, the government should ban the import of inefficient electronic goods, besides, to encourage efficient and user-friendly electronics equipment at local industry and international trade. Consequently, it would be beneficial for sustainable environment in every sector. The results specify that electricity consumption and its key factors found short-run and long-run causality in most cases in Pakistan.

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Dedication

I would like to dedicate this work to my family, mentors, and friends.

Conflicts of Interest

There are no conflicts to declare.

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