ISSN: 1563-2415 (Print), ISSN: 2959-0469 (Online)

Статистика, учет и аудит, 1(100)2026. стр. 5-20
DOI: https://www.doi.org/10.51579/1563-2415.2026.-1.01

Statistics, accounting and audit
SRSTI 06.52.13
UDC 311.33

ENERGY DYNAMICS AND ECONOMIC PERFORMANCE: A VECM AND COINTEGRATION ANALYSIS

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Abstract. *The study seeks to highlights and estimates the impact of energy supply on the industrial and agricultural productivity during 1985 – 2024. Various Econometric tests were also applied on the data. This study uses Vector Error Correction Model and Johnson co-integration test to examine the impact of the Regressors i.e. Electricity supply, Renewable energy, Oil Fuel energy, Energy imports, Fossil Fuel energy, Technology and Labor Force on the dependent variables i.e. Agricultural Productivity, Industrial Productivity and Economic Growth of the economy. The results show that there are strong significant and positive influences of all the independent variables on dependent variables in long run, where a short run relationship observe only in the variables i.e. Electricity supply, Renewable energy, Oil Fuel energy and Technology. Furthermore, the evidence from empirical outcome recommends that efforts should be made to increase the local production of energy i.e. fuel, oil, electricity etc. In addition, some alternative sources of energy like solar power, coal and wind power etc. should be encouraged, so is to increase the productivity of agricultural and industrial commodities which will reduce per unit cost. Hence, increase the GDP and the private sector is encouraged to produce and distribute the electricity.*

Keywords: *productivity, renewable and non-renewable energy, economic performance, VECM, technology, econometric methods, economic growth.*

Main provisions. The study applies the Vector Error Correction Model (VECM) and Johansen co-integration test to analyze the long-run and short-run relationships between energy supply variables and economic outcomes from 1985 to 2024. It finds strong, positive, and statistically significant long-run effects of electricity supply, renewable energy, oil fuel energy, energy imports, fossil fuels, technology, and labor force on agricultural productivity, industrial productivity, and economic growth. In the short run, only electricity supply, renewable energy, oil fuel energy, and technology show significant relationships. The results suggest that expanding domestic energy production and promoting alternative energy sources can enhance productivity and economic growth.

Cite this article as: Rehman F.U., Bozhko L.L., Bayazitova I.A. Energy dynamics and economic performance: a vecm and cointegration analysis. *Statistics, accounting and audit.* 2026, *1*(100), 5-20. DOI: https://www.doi.org/10.51579/1563-2415.2026.-1.01

Introduction. In the current global economic landscape, countries are pursuing sustained growth to enhance their competitiveness and strengthen their position in the development trajectory. Growth in manufacturing sector is one of the numerous reasons of growth and development of any country. These nations changed their agricultural system to industrialization and created such conditions that attracted investors to invest in the creation of new firms and further productivity of the old ones. With the entire transformation of the world brought about by globalization, most challenges surfaced and energy ranked high on the list of issues that researchers focused on [1, 2]. As far as supply is concerned, this globalized world is constantly growing in terms of demand of energy; energy crisis has cropped up. Most of the countries are experiencing shortage of energy hence it is highly impacting their economic development and social change. The views and ideas that could make linkage between energy and economic development are many. Energy is regarded as a pillar of any economy and has significant contribution to socio-economic development of any country. Without adequate amount of energy, industrialization will not occur, it is essential to the operation of industries and output units, to the residual and commercial consumption and transportation, etc. Expansion in energy is likely to cause increase in growth in the same manner that its deficiency can intercept the growth process. To put it in a word, all the resources and energy crisis directly affect all the sectors of economy including the agricultural sector, the industrial sector, unemployment, poverty, decreased GDP and increased inflation [3]. The world development grew a lot since the industrial revolution, following World War - II that augmented the use of energy. The increase of the production i.e. Agricultural and industrial sector also increases the consumption of the energy. To the global economy, 2.5 percent of the energy utilized in agricultural sector is out of final consumption as well as 38.8 percent energy utilized in intermediary production in industrial sector. The remaining energy is used in other areas of the world, such as transports and household among others [4]. It distinguishes various trading patterns of various economies with the division of energy trade between the intermediate production and the final consumption. The consumption of energy in the World has been rising steadily in the last 50-years owing to the improvement in productivity. The fact that the population in the less developed countries, such as Pakistan, Nepal and India is growing indicates that the amount of energy being consumed in the World is going to be even greater, because the reason behind this is that as population grows, the pressure on production and energy will also increase, which will translate to the increased consumption of energy [5]. The production of energy also became faster in response to the rise of consumption in the energy produced. In this case, FDE oil is the highest percentage of maximum followed by natural gas and coal that increases over 280 percent and 280 percent respectively. This was an increase in the same period energy which is generated by hydroelectric sources to 16.20, natural gas was 22.50, coal was 40.40, nuclear was 10.90, renewable was 5% and Oil was 5%.

The effect of energy on output was explained by [6]. They established a lot of influence of energy on productivity. The research paper explores causality of energy consumption to output growth in Canada using short-run analysis whereby we use the vector error-correction model. Following it by Johansen co integration technique empirical results that indicate that the long run use of energy, labor, capita and productivity in Pakistan [7]. Using VECM and Co integration technique, Kakar and khilji argued that there is long run relationship between oil, electricity energy and productivity of agricultural commodities in India. They discovered that, as the supply of oil and electricity also increase so does the production of agriculture [8]. [9] researched the correlation between energy and economic

development of the Pakistani economy. They analyzed that economic growth also increases as there is an increase in energy supply, since the per capita production will increase consequently increasing the rate of increase of GDP of the nation. Asafu-Adjaye examined the causality link between energy consumption and economic growth of the given developing economy i.e. Pakistan, Nepal, India etc. he discovered uni-directional Granger causality between energy and economic growth in India and Indonesia, and bi-directional causality between energy and GDP in the Philippines and Thailand. He observed positive correlation between the consumption of electricity and economic growth in a significant manner and also there is also bi-directional causality between economic growth and consumption of petroleum products and no causal correlation in the consumption of natural gas in Pakistan. In order to achieve this, Pakistan economy would have to seek and generate cheap and abundant sources of energy within the coming years.

Thus we are attempting in this paper to analyze whether the energy has something to do with the increased industrial and agricultural productivity, in the Pakistan economy. We further pay attention to the importance of energy to boost the economic growth. In simple this paper discusses how can supply of energy enhances productivity and economic growth.

Objectives of the Study:

The main objectives of the study are as follows:

1 - To examine and determine the impact of energy supply on industrial productivity

2 - To observe the role of energy supply in agricultural productivity.

3 - To find out the influence of energy supply on economic growth.

4 - To give policy recommendations.

Hypothesis of the Study:

Based on the study we make the following alternative hypothesis. On the completion of the study the researcher will decide that either except or reject the hypothesis on basis of empirical estimations.

H_1: Increases in energy production will boost industrial productivity.

H_2: Improvement in energy production will accelerate Agricultural output. H_3: Rise in energy supply will increases economic growth.

Literature Review. The effect of electricity on productivity depends on the countries. Most of the countries found positive impacts of electricity on productivity, whereas some of the countries have negative and insignificant impacts of electricity production on the productivity of the economy [10]. Gosh presents an argument in favor of impact electricity supply to the productivity of industries in the country. He established that the chosen variables were significantly correlated [11]. Karanfil compares nexus between electricity, employment and real GDP in India and apply more valid econometric methods i.e. ARDL and established strong relationship among the variables selected.

The relationship is established between natural gas and productivity of industrial sector. With the help of the short run result of vector error correction model and long run result of co- integration test, as well as negative influence of the prices of natural gas on the production of industrial sector. The generation is heavily correlated with production, economic, industrial and trade activities of Pakistan [12]. Based on his findings generation of industries are adversely impacted owing to the prevailing industrial, financial and energy crisis. Industries keep closing down the workers will be left jobless and will overtake streets. In case industry is more productive, exporting, and competitive in the international market, they will be responsive to the energy needs [13]. This is because Siddiqui observed the supply of energy and productivity of the country. He detected little harm in the case of Pakistan and

any crisis arising due to energy will mean a road block to productivity and economic development. Petroleum products and electricity impact is also very high. By using various econometric tools, Khurshid and Anwar, have approximated that the effect of energy such as oil, natural gas and electricity has been positive and significant to the textile and sugar sector in Pakistan. The key ratios of textile industry as explained by Shah, Essrani, Shah, and Rahat show that the performance of textile industry is heavily impacted in the post energy crisis period compared to before energy crisis period [14]. Afzal examined the energy supply and production in textile industry in Pakistan using multiple linear regression analysis of independent variables i.e. electricity consumption and interest rate, the results indicate that there is negative relationship between output of the textile industry and the use of energy, and also between textile industry and interest rate.

The consequences of the energy supply and productivity of industries in Pakistan has been popularized by Qazi, Ahmed and Mudassar. Long run results were done using Johansen co-integration test whereas the short run results were done using Vector Error Correction (VECM). The empirical results were able to establish the positive correlation that existed between energy supply and industrial productivity, bi-directional causality as oil supply, uni-directional causality as the use of electricity in industrial output and the output of industries in terms of coal use, and in the case of natural gas supply no causality at all. Presented in a study, Chaudhry, Safdar, and Farooq used tools in the forms of Granger causality tests, econometric analysis, correlation analysis, to reveal that GDP of Pakistan is dependent on energy supply that incorporate electric energy, oil, coal and gas due to the reasons that when the supply of energy is higher the economy acceleration of the economy will be boosted and hence the economic growth increases. In addition, empirical findings demonstrate the unidirectional causality to be observed in trade. By applying Structural Vector Auto-regression Model, it is observed that economic growth raises the demand of both capital stock, energy consumption and labor force. The government of Pakistan needs to provide affordable energy to enable growth and production. By using the data of the time series of Taiwan in the period 1955 to 2003, Chiang and Chang approximated the linear and non-linear impact of the energy supply such as electricity, natural gas, minerals and coal etc. on the industrial output which has a direct influence on the GDP. The Results of the study is an evidence of the fact that the correlation between economic development and energy consumption in Taiwan is indirect and U- shape. Nonetheless, empirical finding confirms that similar connection can only be concluded to exist when there is a limited degree of energy consumption in Taiwan. Another issue discussed in this Study was that the threshold regression model offers better empirical findings than the regular linear model to the policy makers.

Gap of Energy and Productivity. Pakistan is currently facing a severe energy crisis that has significantly affected its economic performance. As a developing economy and a non-oil-producing country, Pakistan relies heavily on imported oil to meet its energy demands. The infrastructures of Pakistan energy have not been developed properly and reported to be poorly managed. With the expansion of the population, there was lack of any serious efforts to generate energy regardless of the economic growth and improved demand in the past decades.

The three main energy resources of Pakistan utilized to meet the energy demand of the economy are Nuclear, Thermal and Hydel. The nuclear source of energy contribution to the generation of power of Pakistan is 2.4 percent of the total power generated, thermal source is approximately 65.20 percent of the total power generation, and Hydel source accounts to 33.9 percent of the total power generation. Pakistan is experiencing imported mass-quantity of

petroleum products due to the low amount of oil reserves and political system, particularly that of Saudi Arabia. The industrial, financial and energy crisis at the present time severely impacts the production of Agricultural, industrial sectors and trade activities of Pakistan. The workers will become jobless and will occupy the streets as the industries keep closing down. Government in other countries of the world supports industries by giving them lots of incentive, inputs at a low cost that in turn enhance the productivity, competitiveness and exports in the global market and consequently swell up their economy. However, in Pakistan, most industries do not have the in house capability to generate power and also lament over hefty taxes and expensive power supply that is constantly hampered leading to loss of output production, particularly to the textile industry that has minimal exports and are being closed or relocating to the neighbor countries [15].

In the 1980s, 86 percent of domestic manufacturing industry was satisfied with home energy production and the remaining demand of the energy was supplied through imports. This demand-supply imbalance is aggravated by the year 2000 to 47 percent. Consequently, this reduced the demand-supply spaces of the energy to 0.4 percent in the year 2005, equilibrium in the year 2003, as the greater part of this increase in supply was achieved by the expansion of the supply of natural gas. Electricity, coal and oil are the other major sources of energy employed in fuel consumption.

These two primary economic sectors i.e. industrial and agricultural sectors saw rise in consumption of energy in 200s, see figure-1. The rise in the percentage of agriculture consumption of electricity is good indication that farmers are now enjoying electricity to farm mechanization which will have spill over effect to the entire economy. Nevertheless, when the current trend in terms of growth of demand of the energy is projected, the energy consumption in the nation is estimated to be 150-million-ton oil equivalent (MTOE), but the supply would be 103 MTOE. The imports in the short run and the government investments in the long run in this sector would satisfy this gap of about 31 percent. Since the percentage of energy consumption in Pakistan in the previous decade (1995 -96 to 2004 -05) soared to very high levels due to the increase of production that contributes a higher percentage to the economic growth i.e. 5.1% 2002 -03, 6.3% in 2003-04 and 8.4% in 2004-05 to maintain the growth rate [7].

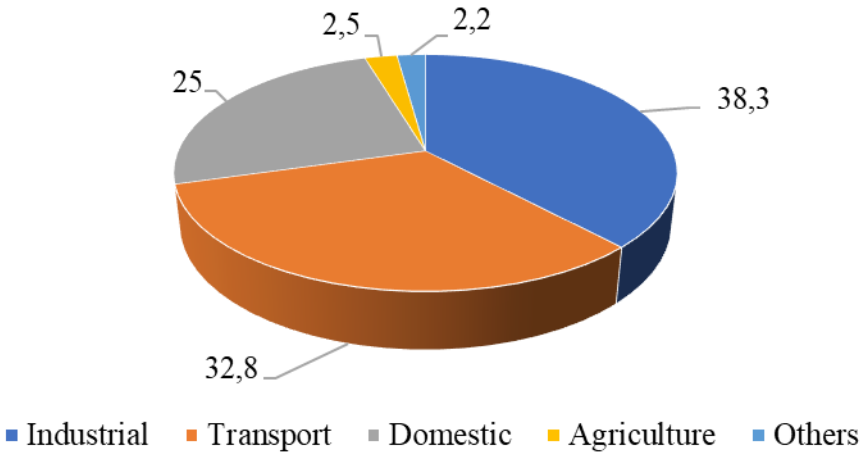

Figure 1 – Energy Consumption by Sector-Wise
Note: Energy Yearbook, Various issues

These problems such as, privatization / efficiency, energy demand, energy and economic growth, rural electrification / independent power producers, need for an energy policy, alternative and renewable energy are presently facing the energy sector in Pakistan. In order to reduce such issues of energy government of Pakistan exploring and producing energy such as in Khyber-Pakhtunkhwa Pakistan, 1891 Kkm2 area of the KPK is currently being explored to produce oil and gas. In 2004 104440 barrel and 8440 MCF oil and gas production respectively. In 2008-2009 oil production will rise by up to 79740 barrels and gas production by 31360 MCF and FY-2015 oil production up by up to 144567 and gas production up by up to 143670. These steady turns in the energy resources enhance the effectiveness of home-based production such as, sugar mills, textile industry among other agro based industries.

In addition, several initiatives are also initiated in order to make the reforms planned in the Power Policy of 2013 China-Pakistan Economic Corridor (CPEC) sustainable. CPEC projects foresee energy and infrastructure projects and have an approximate financial expenditure of approximately US 46 billion. It is estimated that the cost of projects in the Energy sector is US $ 34.74 billion and the cost of projects in the infrastructure sector is US $ 13.217 billion.

The initiative of China Pakistan Economic Corridor (CPEC). CPEC shall generate 73 percent power coal, 15 percent power Hydel, 10 percent power solar and 2 percent power wind energy. This grandiose energy project under CPEC will increase economic development and economic growth of the economy. The abundance of energy will make the industrial and Agricultural sector more productive and hence the exports of the country will also increase.

Materials and methods. This study uses the secondary data during 1985 – 2024 on Energy Prices. The dependent variables of the study are Industrial Productivity (i.e. Textile mills productions and others overall major production of domestic manufacturing industries), Agricultural Productivity (i.e. forestry, and fishing, as well as cultivation of crops and livestock production) and Economic Growth of Pakistan. The rest of the following variables in the Model, 1, 2 and 3 are independent variables. The data sources include Economic Survey of Pakistan, Pakistan Statistical Year Book, Agricultural Statistics of Pakistan, Publications of Federal Bureau of Statistic, World Bank Development and so on.

The Models:

$$AP=\beta o + \beta_1 T + \beta_2 LF + \beta_3 ES + \beta_4 CA + \beta_5 RE + \beta_6 FFE + \beta_7 EI + U \quad (1)$$

$$IP = \beta o + \beta_1 LF + \beta_2 ES + \beta_3 EI + \beta_4 OE + \beta_5 RE + \beta_6 T + U \quad (2)$$

$$GDP = \beta o + \beta_1 ES + \beta_2 OE + \beta_3 EIM + \beta_4 FFE + \beta_5 RE + U \quad (3)$$

Whereas:

IP = Industrial Productivity - AP = Agricultural Productivity

ES = Electricity Supply - OE = Oil Energy Supply

GDP = Gross Domestic Product - FFE = Fossils Fuel Energy

CA = Capital Availability - EM = Energy Imports - U= Error Term

Unit Root Test:

Unit Root is one of Econometric Test which is employed to examine the stationarity of the time series data. The data of the selected variables will be stationary if variance, co-variance and its mean remains constant over time [16].

Consider the AR (1) model;

$Yt = Ø\ Yt\text{-}1\text{-}\epsilon t$

The justification is as.

Case: 1. $Ø < 1$ hence the data is stationary.

Case: 2. Ø > 1where in this case the series explodes.

Case: 3. Ø=1 where in this case the series includes the unit root is nonstationary.

Augmented Dickey – Fuller Test (ADF)

The growth of Dickey-Fuller is augmented. It is applied to be higher order absence of the dependent variable to investigate the Auto-correlation issue. Various researchers such as, kakar and khilji [10] and Shahbaz and Feridun [8] also list the three possible types of ADF test with the following equations [6,7].

$$\Delta Yt = \gamma Y t\text{-}1 + \Sigma^{P}_{i}=1\ \beta_i\ \Delta Yt\text{-}1 + \mathfrak{C}t$$
$$\Delta Y = \dot{\alpha}_o + \Upsilon Yt\text{-}1 + \Sigma^{P}_{i}=1\ \beta_i\ \Delta Yt\text{-}1 + \mathfrak{C}t$$
$$\Delta Y = \gamma Y t\text{-}1 + \dot{\alpha}2t + \Sigma^{P}_{i}=1\ \beta_i\ \Delta Yt\text{-}1 + \mathfrak{C}t$$

It is highly necessary that the researcher underline the effect of the energy supply on the agricultural and industrial output in Pakistan (i.e. manufacturing) that in case the variables are to be integrated of order second difference I(2) or greater the calculated F-statistics turn out to be null or known as spurious regression [17]. Because of this important consideration, the use of Augmented Dickey Fuller test is aimed at tracking the order of integration between the variables. Table-1 results indicate that the all entire variables are of order I(1) and none of the variables is of order I(2) and above and 1(0) which clearly indicate the Vector Error Correction Model (VECM) estimation methodology of short-run. The use of Johnson Co-integration test is aimed at studying whether a long-run correlation between the chosen variables exists. The strength of this model is that it is fast to change.

Results and Discussions. In this model the study select the variable i.e. Agricultural productivity (AP) is a dependent variable and the rest of variables like, ES, EI, RE, OE, CA, LF, T, FFE and NE are independent or regressors of the study. Table-2 presents that there are long run relationship among the selected variables. In the Trace Statistics, estimated values are significant at 5% level up to the variables at most 5, for example, at most 1, 2, 3, the estimated values are 370, 268, 195 and 5% critical values are 197, 159, 123 respectively. The estimated values are greater than the critical values (table-2) it's clearly show the long run relationship among the selected variables and also in the Max-Eigen Value, estimated values are also significant up to at most 4. The estimated value of Max-Eigen show are 101, 73, 69 and 5% critical values are 58, 52, 46, respectively here also estimated values are greater than critical values up to at most.

Table 1 - Results of Augment Dickey Fuller Test

Variables	At Level	At First Difference	Stationary Remarks
IP	-1.33 (0.379)	-7.388 (0.00)*	1(1)
AP	-1.97 (0.59)	-5.466 (0.00)*	1(1)
GDP	-1.357 (0.47)	-6.56 (0.00)*	1(1)
ES	-1.45 (0.82)	-6.102 (0.00)*	1(1)
EI	-2.79 (0.21)	-4.48 (0.00)*	1(1)
RE	-1.17 (0.89)	-4.09 (0.01)*	1(1)

continuation of table 1

OE	-0.61 (0.98)	-5.21 (0.00)*	1(1)
CA	-2.59 (0.14)	-8.487 (0.00)*	1(1)
LF	-2.37 (0.383)	-5.82 (0.00)*	1(1)
T	-1.48 (0.35)	-5.40 (0.00)*	1(1)
FFE	-1.92 (0.618)	-4.44 (0.00)*	1(1)
NE	-2.39 (0.37)	-5.47 (0.00)*	1(1)
Note: The researcher estimations. Please note that 1(0) shows at level, 1(1) indicates integration at first difference. The values in bracket are the probability values and the rest are t-statistics. The single and the double * are important since at level 5 and 10 respectively, the variables are significant.			

$$AP=\beta o + \beta 1T + \beta 2LF + \beta 3ES + \beta 4CA + \beta 5RE + \beta 6FFE + \beta 7EI + U \quad (1)$$

Table 2 - Results of Johan-sen Co-integ-ration Test (Mod. – 1)

Hypo.			Trace-stat.		MaxEigen Val.	
Null	Alternative	CE(s)	Estimated value	5% Crit. Val.	Estimated val.	5% Crit. Val.
r=0.	r=1.	None.*	370.47 (0.001)*	199.37	101.63*	58.43
r<1.	r<2.	At most.1*	268.83 (0.004)*	150.53	73.10*	52.36
r<2	r<3	At most 2*	195.64 (0.000)*	125.61	69.77*	46.23
r<3	r<4	At most 3*	125.87 (0.000)*	95.73	43.47*	40.07
r<4	r<5	At most 4*	82.39 (0.003)*	69.81	35.72*	33.87
r<5	r<6	At most 5	46.66 (0.064)*	47.85	24.57	27.58
r<6	r<7	At most 6	22.09 (0.293)	29.79	14.07	21.13
r<7	r<8	At most 7	8.02 (0.463)	15.49	8.01	14.26
r<8	r<9	At most 8	0.00 (0.93)	3.84	0.00	3.84
Note: The values in bracket are the probability values and the rest are t-statistics. The single and the double * are important since at level 5 and 10 respectively, the variables are significant.						

According to Gujarati and Porter when the estimated value of Max-Eigen and Trace Statistics are greater than its critical values it means that there are long relationship exist in the selected variables of the model. It means that with the increase in the selected type of energy the Agricultural output may boost up in Pakistan's economy. Moreover, the * also

denotes the long co integration among the variables in the Johnson Co integration analysis. The same study was also given by Wu, X. F. and Chen Q. G. [18] and Roddy D., J., A.

Table 3 – Results of VECM Analysis in Short-Run (Model – 1)

Variables	Coefficients	Std. Error
T	0.58*	0.10
LF	0.001	0.000
ES	3180*	1253
CA	21	542
RE	7249*	2245
FFE	10903	3803
EI	1990	1699
C	533665*	240285
R^2	0.93	
Adj. R^2	0.91	
F-statistics	51.12	
D. W Stat	2.4	
Note: * show significant at 5% level.		

Table 3 shows the R^2 is 0.93, which show that 93% changes in dependent variable are due to independent variables. Adjusted R^2 is 0.91, which is much closer to R^2, its clearly present that the model is good fit. In this Regression Analysis F-statistics is 51.12 its means that the Econometric Model is highly significant in short run and the prob. (F-statistics) is 0.000. The D.W. Stat: is 2.4, which show that there is no problem of Autocorrelation [17].

There is positive and significant at 5% level impact of regressors i.e. Technology (T) on dependent variable i.e. Agricultural productivity (AP) (Table 3). It means that when Technological power of the economy goes up the output of Agricultural sector also increases. The influence of Labor Force (LF) on AP is positive and insignificant. The sign of the independent variable is correct according to economics theory but it's insignificant due to the reason that most of Agricultural sector are no more labor intensive, it's become capital intensive in Pakistan. The study uses the LF is a independent variable because its one type of energy i.e. Human power energy. According to Economic Theory when supply of electricity (ES) increases the output is also increases. Because due to modernization of agricultural sector most of agricultural activities are done by machinery which needs power to run. In our analysis there is positive relationship between power supply energy and output of agricultural commodities with significant impact. The influence of Capital (C) (i.e. which make consumers good) on Agricultural Productivity is positive which means that when no. of modern machinery increases it will save time and decrease cost which leads to increases the output of agricultural sector in Pakistan. In our case the t-statistics of the variable is 0.04 which is off course insignificant. Pakistan is developing country so they cannot meet the requirements of agricultural capital to make modern so this why it's insignificant. This study suggests that there is positive relationship between Renewable Energy (RE) and output of agricultural is positive its means that when renewable energy i.e. solar energy rises up productivity also increases. In Table 3 the t-statistics is 3.22 which is significant at 5% level. According to the study results the role of Fossils Fuel Energy (FFE) like, coal, energy from dead body of animals and plants when they destroy is positive but insignificant. In respect of agricultural sector this energy is rarely uses so that's why it's insignificant impact on dependent variable. The impact of independent variable i.e. Energy Imports (EI) on dependent

variable i.e. Agricultural Production is positive but insignificant. It means that when the economy of Pakistan increases the imports of energy, like petroleum, Diesel, etc. the production increase but the influence is weak here, because when a country increases the imports of the energy its increases the cost of production, so that why the impact is insignificant.

$$IP = \beta o + \beta 1LF + \beta 2ES + \beta 3EI + \beta 4OE + \beta 5RE + \beta 6T + U \quad (2)$$

Table 4 - Results of Johansen Co-integration Test (Model – 2)

Hypothesis			Trace statistic		Max-Eigen. Val.	
Null	Alternative	CE(s)	Estimated value	5% Crit. Val.	Estimated value	5% Crit. Val.
r=0.	r=1	None*	458.85 (0.007)*	196.37	125.09*	58.43
r<1.	r<2	At most 1.*	333.76 (0.009)*	157.52	114.11*	52.36
r<2	r<3	At most 2*	219.64 (0.001)*	123.61	82.59*	46.23
r<3	r<4	At most 3*	137.05 (0.000)*	95.73	44.82*	40.07
r<4	r<5	At most 4*	92.22 (0.000)*	69.81	34.84*	33.87
r<5	r<6	At most 5*	57.38 (0.005)*	47.85	27.40*	27.58
r<6	r<7	At most 6*	29.98 (0.04)*	29.79	18.46	21.13
r<7	r<8	At most 7	11.51 (0.18)	15.49	11.50	14.26
r<8	r<9	At most 8	0.014 (0.90)	3.84	0.014	3.84

Note: The values in bracket are the probability values and the rest are t-statistics. The single and the double * are important since at level 5 and 10 respectively, the variables are significant.

In present model the study selects variables, i.e. Industrial Productivity is a dependent variable and the rest of variables like ES, EI, RE, OE, CA, LF, T and FFE are independent variables of the study. Table 4 presents that there are long run relationships among the selected variables. In the Trace Statistics, estimated values are significant at 5% level up to the variables at most 6, for example, at most None, 2, 3, the estimated values are 458, 333, 219 and 5% critical values are 197, 159, 123 respectively. The estimated values are greater than the critical values (table-3) it's clearly show the long run relationship among the selected variables and also in the Max- Eigen Value, estimated values are also significant up to at most 4. The estimated values of Max-Eigen show are 125, 114, 82 and 5% critical values are 58, 52, 46, respectively here also estimated values are greater than critical values up to at most 4. According to Gujarati and Porter when the estimated value of Max-Eigen and Trace Statistics are greater than its critical values it means that there is long relationship exist in the selected variables of the model. The results of the study highlights that increase in such type of energy

economy may accelerate the industrial productivity. Moreover, the * also denotes the long co integration among the variables in the Johanson Co integration analysis.

Table 5 - Results of VECM Analysis in Short-Run (Model – 2)

Variables	Coefficients	std. Error
LF	5.7	1.4
ES	0.36	0.31
EI	1.14*	0.54
OE	0.15	0.09
RE	0.31	0.79
T	5.0	4.68
Constant	0.034	0.93
R^2	0.40	
Adj. R^2	0.21	
F-statistics	2.12	
D.W. Stat.	1.96	
Note: * show significant at 5% level		

In this study, Table 5 shows that 40% changes in dependent variable are due to independent variables only in short run., which is not such much closer to R^2. In this Regression Analysis it means that the Econometric Model is significant in short run at 10% significance level and the prob. (F-statistics) is 0.08. The D.W. Stat: is 1.96, which shows that there is no problem of Autocorrelation [17].

The impact of Labor Force (LF) on dependent variables is positive with insignificant impact (Table 5). The insignificancy is due to industrial modernization [19]. The rapid pace of structural changes in the manufacturing process, producer shift from labor to capital intensive method, due to that reason time and per capita output cost is lower, which leads to boost up profit.

Table 6 - Results of Johansen Co-integration Test (Model – 3)

Hypothesis			Trace statistic		Max-Eigen Value	
Null	Alternative	CE(s)	Estimated value	5% Crit. Val.	Estimated val.	5% Crit. Val.
r=0.	r=1.	None*	305.64 (0.005)*	151.52	92.09*	52.36
r<1.	r<2	At most1*	213.55 (0.003)*	123.61	69.74*	46.23
r<2	r<3	At most 2*	143.80 (0.001)*	95.75	56.64*	40.07
r<3	r<4	At most 3*	87.167 (0.001)*	69.81	39.169*	33.87
r<4	r<5	At most 4*	47.99	47.85	25.97*	27.58
			(0.04)*			
r<5	r<6	At most 5	22.02 (0.29)*	29.79	15.17	21.13
r<6	r<7	At most 6	6.84 (0.59)*	15.49	6.35	14.26
r<7	r<8	At most 7	0.49 (0.47)	3.84	0.49	3.84
Note: The values in bracket are the probability values and the rest are t-statistics. The single and the double * are important since at level 5 and 10 respectively, the variables are significant.						

The impact of imports of energy (EI) is positive but insignificant impact and significant on industrial output. The results of the study present that when energy supply from foreign countries increases its boost up the domestic output. The influence of Renewable energy (RE), Oil energy (OE) and Technologies on industrial productivity is positive. It obviously highlights that with the increase of that type of energy it accelerate the productivity of the economy of Pakistan.

$$GDP = \beta o + \beta_1 ES + \beta_2 OE + \beta_3 EI + \beta_4 FFE + \beta_5 RE + \beta_6 T + U \quad (3)$$

In the Co-integration analysis the study selected the variable i.e. Economic Growth (GDP) is a dependent and the rest of variables like, ES, EI, RE, OE, CA, LF, T and FFE are independent variables of the study. Table 6, reveals that there are long run relationship among the selected variables. In the Trace Statistics, estimated values are significant at 5% level up to the variables at most 4, for example, at most None, 2, 3, the estimated values are 305, 213 and 97 and 5% critical values are 159, 125, 95 respectively. The estimated values are greater than the critical values (table-4) it's clearly show the long run relationship among the selected variables and also in the Max-Eigen Value, estimated values are also significant up to at most 4. The estimated value of Max-Eigen show are 92, 69, 56 and 5% critical values are 52, 46, 40 respectively, here also estimated values are greater than critical values up to at most 4. According to Gujarati and Porter when the estimated value of Max-Eigen and Trace Statistics are greater than its critical values it means that there are long relationship exist in the selected variables of the model. Moreover, the * also denotes the long co integration among the variables in the Johanson Co integration analysis. The results of johanson Co-integration analysis clearly show that with the increase of the selected independent variables will leads to increase the Gross Domestic Product of the Pakistan's economy.

Multicollinearity Problem Test Result: According to Rule of Thumb, the problem of Multicollinearity arises if R^2 of the model is < 0.80, the F-test in the majority cases will reject the hypothesis that the partial slope co-efficient are simultaneously equal to 0, but the individual t-test presents that none or very few of the partial slope coefficient are statistically different from 0 [20]. In this study the value of R^2 of the model-1 is 0.93, and our most of variables are significant at 5% level. It's quite clear that there is absence of Multicollinearity problem. In the model-2 the R^2 value is 0.40 which is less than 0.80.

Autocorrelation problem Test Result: When the value of D.W is 2.0 or near to 2.0 in the model it means that there is no problem of Autocorrelation. In this study the value of Durbin – Watson statistic in the model-1 is 2.4 and, in the model,-2 the value is 1.96 which indicates that there is absence of Autocorrelation problem in the model. Augmented Dickey Fuller test is used for detection of Autocorrelation problem.

Conclusion. The consumption of energy in Pakistan is increase from 2000, because of advancement of agricultural and industrial sector. The rapid changes in structural and technological changes both sectors use capital intensive method instead of labor intensive, so that's why in our analysis labor force is insignificant in the selected model, and most of energy type is significant.

The impact of electricity supply on agricultural and industrial productivity is positive and significant (coefficient is 3180). It means when production of electricity increases, the productivity will be boosted up. Similarly, the influence of Renewable energy on productivity is positive and significant (coefficient is 7249). Its highlights are that with the increase of production of solar energy, coal etc. should be on a large scale which will increase the

productivity of the domestic industries i.e. industrial and agricultural sectors. The relationship between capitals, i.e. modern technology and productivity, is positive, which presents capital intensive method cost and production cost are decreases which leads to increase the productivity. Furthermore, the Oil imports, Fossil Fuel energy and labor force have positive impact on productivity but are insignificant in short run, but significant in long run. The analysis of this study explores that there is strong long run relationship among the selected variables in both of the models, while in short run some of the variables have insignificant effects like, labor, force, oil imports fossil fuel energy.

Policy Recommendations:

- It is suggested that efforts should be made to increase the local production of energy (i.e. fuel, oil and electricity etc.). In addition, some alternative sources of energy like solar power, wind power etc. should be encouraged, so it is to increase production which will reduce per unit cost. Also, the private sector is encouraged to produce and distribute electricity.
- It is recommended that government should produce and import high technologies from developed countries so that the time cost and per capita output cost are decreased hence productivity will be boosted up.
- It is recommended that government should encourage the production of agricultural commodities. As a policy measure, we need to exploit our unrealized yield potential in production of agricultural commodities.
- Government should control strategic planning and management.

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ЭНЕРГЕТИКАЛЫҚ ДИНАМИКА ЖӘНЕ ЭКОНОМИКАЛЫҚ КӨРСЕТКІШТЕР: VECM ЖӘНЕ КОИНТЕГРАЦИЯЛЫҚ ТАЛДАУ

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Түйін. *Энергетикалық қауіпсіздік мемлекеттің және жекелеген тұтынушылардың энергетикалық мүдделеріне нақты және әлеуетті қауіп-қатері болмайтын мемлекеттің ішкі және сыртқы жағдайы ретінде қарастырылады. Зерттеу Пәкістандағы 1985–2024 жылдар аралығындағы өнеркәсіп пен ауыл шаруашылығының дамуына энергиямен жабдықтаудың әсерін эмпирикалық тұрғыдан бағалауға бағытталған. Мақалада қателіктерді түзетудің векторлық моделі және Йохансен коинтеграция тесті ұсынылған, олар энергиямен қамтамасыз ету, жаңартылатын энергия көздері, энергия тасымалдаушыларын импорттау, технологиялар, жұмыс күші және басқа да факторлар сияқты регрессорлардың ауыл шаруашылығы мен өнеркәсіптегі өнімділікке, сондай-ақ елдің экономикалық өсіміне әсерін бағалауға мүмкіндік берді. Мақалада зерттелген факторлардың әсері бойынша қорытындылар жасалған: барлық тәуелсіз айнымалылар ұзақ мерзімді кезеңде тәуелді айнымалыларға оң ықпал етеді, ал қысқа мерзімді өзара байланыс тек электрмен жабдықтау, жаңартылатын энергия көздері, мұнай отынына негізделген энергетика және технологиялар сияқты құрамдас бөліктер бойынша ғана байқалады. Қорытынды бөлімде Пәкістанның жеке секторын электр энергиясын өндіру және тарату саласына қолдау көрсету мен ынталандыруға бағытталған ұсыныстар келтірілген.*

Түйінді сөздер: *өнімділік, қалпына келетін және қалпына келмейтін энергия көздері, экономикалық көрсеткіштер, VECM, технологиялар, эконометрикалық әдістер, экономикалық өсу.*

ЭНЕРГЕТИЧЕСКАЯ ДИНАМИКА И ЭКОНОМИЧЕСКИЕ ПОКАЗАТЕЛИ: VECM И КОИНТЕГРАЦИОННЫЙ АНАЛИЗ

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Резюме. *Энергетическая безопасность рассматривается как внутреннее и внешнее состояние страны, при котором отсутствуют реальные и потенциальные угрозы энергетическим интересам государства и отдельных потребителей. Исследование направлено на проведение эмпирической оценки влияния энергоснабжения на развитие промышленности и сельского хозяйства Пакистана в период с 1985 по 2024 годы. В статье представлена векторная модель коррекции ошибок и тест коинтеграции Джонсона, которые позволили оценить влияние регрессоров (энергоснабжение, возобновляемые источники энергии, импорт энергоносителей, технологии и рабочая сила и др. факторы) на зависимые переменные, такие как производительность в сельском хозяйстве и промышленности, а также страновой экономический рост. В статье сделаны выводы о влиянии исследуемых факторов: все независимые переменные оказывают положительное влияние на зависимые переменные в долгосрочной перспективе, в то время как краткосрочная взаимосвязь наблюдается только по таким составляющим, как электроснабжение, возобновляемые источники энергии, энергетика на нефтяном топливе и технологии. В заключении приведены рекомендации, направленные на поддержку и стимулирование частного сектора Пакистана к производству и распределению электроэнергии.*

Ключевые слова: *производительность, возобновляемые и невозобновляемые источники энергии, экономические показатели, VECM, технологии, эконометрические методы, экономический рост.*

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Received: 22.12.2025
Accepted: 29.01.2026
Available online: 31.03.2026