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INVESTIGATE THE IMPACT OF ENERGY COSTS ON AGRICULTURAL PRODUCTION IN PAKISTAN

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ABSTRACT

Pakistan, like many other emerging countries, is regarded as one of the most hit by food insecurity, poverty, and natural catastrophes. Approximately two-thirds of Pakistan's population live in rural regions and are directly or indirectly dependent on the agricultural industry for food and income. Furthermore, Pakistan's inadequate adaptive capacity to manage environmental calamities has a harmful impact on agricultural output (AgGDP) and local food security. Therefore, this study inspects the effect of energy cost on agricultural production in the case of Pakistan. To achieve the above objectives, this study used the data from 1973 to 2022 in the case of Pakistan, which was collected from World Development Indicators (WDI) and the Economic Survey of Pakistan, and employed ARDL and other diagnostic tests to estimate the model. This study found that the agricultural land, machinery, labor force participation, petrol/oil, gas, and electricity consumption in the agricultural sector, and water availability have a positive effect on AgGDP. This study concluded that energy cost has an encouraging effect on agricultural productivity. This study recommended that the government should have tight governance, subsidy reforms, farm sector changes, a shift from non-renewable to renewable energy, and monetary policy free of political interference.

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INTRODUCTION

Economic growth is a country's most effective tool for reducing poverty and improving the quality of life. Every country seeks significant economic growth. Poverty reduction is impossible without consistent economic development. As a result, any country should boost economic growth while also improving societal well-being. Capital and labor are the primary drivers of aggregate output in the production function. In general, various elements contribute to economic growth, including physical, human capital, technology, land, commerce, foreign capital inflows, institutional factors, and so on. Each production element serves a distinct purpose in the manufacturing process (Azam, 2020). Energy plays an important part in manufacturing. Several consuming and manufacturing activities have used energy as a primary input. Similarly, energy has been referred to be the 'lifeblood of society' due to its vital function in supporting life through various activities. Thus, in addition to other fundamental elements, the accessibility of energy is equally important in initiating and maintaining GDP growth (Azam, 2020).

The agricultural sector encompasses with crops, livestock, fisheries, and forestry. The sector is responsible for income and employment sources for households. Cumulatively, income earned and contributed by this sector is referred to agriculture gross domestic product. Numerous policies and programs need to be instigated to support the growth in the agricultural sector, such as providing subsidies for agricultural inputs, expanding irrigation facilities, and promoting the adoption of modern technologies in the country. Despite facing numerous problems such as water scarcity, low productivity, and climatic threats, the agriculture sector of Pakistan continues to add remarkable contributions to the country's economy and remains a key source of livelihood for millions of people. Agriculture is a significant contributor to Pakistan's GDP, accounting for over 20 percent. However, the sector faces challenges such as energy costs, water scarcity, and climate change impacts. These challenges have led to lower productivity and incomes for farmers. The government had launched initiatives to address these challenges, including investment in irrigation infrastructure and crop diversification (Khan, 2020).

Nothing is more vital to humanity's future than whether agricultural output can keep up with rising population and income-driven demand for food (Naylor, 1996). The agricultural business is one of the most important industries for countries across the world, since it has long been associated with many facets of national development (Chen et al., 2020a). To begin, agriculture is the foundation of FS (Gebbers and Adamchuk, 2010), however, the world's continued growth of population and consumption has stimulated food demand for at least 40 years (Godfray et al., 2010). Second, according to the World Bank (2023), statistics, the average %age of yearly GDP for the agri-industry accounted for more than 30.00% of the total country's GDP in 2016, despite the fact that worldwide agriculture percentages were decreasing. Third, agricultural growth increases a country's employment rate (Kuznets and Murphy, 1966). Fourth, agriculture may be a driving force in reducing poverty in a country (Cervantes-Godoy and Dewbre, 2010). Moreover, AgM has reduced the usage of human as well as animal power in this business year after year (Ozkan et al., 2004). The fast development of AgM and farm technology has led to increased energy consumption in agricultural sectors (later on AgEC), which is strongly tied to farm environmental and economic concerns (Soni et al., 2013). Agriculture has contributed to a small fraction of many countries' energy use (later on, EC). Energy usage has been identified as the most expensive input for growing greenhouse crops (Hassanien et al., 2016). Another study discovered that oil products are the greatest AgEC (Soni et al., 2013).

Many of the world's most productive agricultural basins rely on groundwater. The availability of groundwater affects the food that customers eat, the farmers who produce it, and the local economy that sustains it. Agriculture consumes around 70.00% of the water taken or diverted for consumptive use worldwide, but in several groundwater basins, this share can reach 95-99%. Many agri-regions throughout the world rely heavily on energy to collect groundwater for irrigation (Schoengold and Zilberman, 2007). Energy is a critical input for extracting groundwater for irrigation in the High-Plains Aquifer. Rising energy prices are therefore a possible source of worry for agriculture, since they may have an impact on groundwater extraction and crop selection decisions for farmers who rely on electricity to pump water (Pfeiffer and Lin, 2014).

Because energy plays a critical role in every country's economic progress, it increases efficiency and production (Chaudhry et al., 2012). Similarly, energy is considered to be a primary driving force for economic growth in Pakistan. A major portion of oil is used for the production of energy-related products like electricity, along with the heavy utilization in transportation. Thus, electricity is utilized for the manufacturing of industrial and consumer goods. Oil and electricity are both used in the cultivation and harvesting of agricultural crops, which leave a significant impact on either way (Chandio et al., 2019). Abbas et al. (2017) found that energy costs for wheat production in Punjab-Pakistan account for around 22 percent of the total cost of production. They used primary data collected through a survey of 100 wheat growers in the region and analyzed the energy consumption patterns of different wheat production operations, such as land preparation, sowing, fertilizer application, irrigation, and harvesting, and estimated the energy consumption and cost of production for each operation. The outcome exhibited highest consumption of energy made by irrigation phase, accounting for 51 percent of total energy consumption, followed by land preparation 26 percent and harvesting 14 percent. Agriculture farm sector produced products through value addition. Increasing Pakistan's national income and labor force in the labor market by 24 and 51 percent, respectively, has contributed to the country's remittance earnings. The contribution of AgGDP dropped to 0.26 percent because of the negative growth in cotton to 17.5 percent, rice 17.5 percent, and sugarcane to 19.4 percent. Vegetables, oil seeds, and pulse production had shown a progressive growth of 4.5 percent (Economic survey of Pakistan, 2020).

The rise of technology has resulted in increased energy consumption (EC) in the agriculture business. Saving AgEC is becoming just as important as it is in manufacturing, construction, and transportation. The deployment of energy-saving measures should not come at the expense of agricultural productivity, which is strongly tied to human food security. Strong decoupling between EC and GDP suggests that the former falls as the latter rises, which should be pursued by countries (Chen et al., 2020a). Food and Agriculture Organization (FAO) envisaged in its documents that about 820.00 million people throughout the globe are affected by hunger, with two (2) billion people experiencing food insecurity, and the food-deprived people are projected to reach 840 million by 2030. Food scarcities occurred mainly because of natural catastrophes in the past, but with the era of globalization, it became an economic phenomenon rather than an agricultural one. The dynamics of global food market with a combination of food security (FS) and economics access to sufficient food supply, FS at national level is heavily dependent upon the macroeconomic indicators like volatile energy prices, agriculture input prices, foreign exchange rates and money supply at national level (World Health Organization, 2022).

Economic expansion is energy-intensive. Nonetheless, in developing nations such as Pakistan, current agricultural energy consumption patterns are not precisely in line with those in wealthy countries. Sharp increases in energy prices have major ramifications for Pakistan's rural economy (Mushtaq et al., 2007). Pakistan, like many other developing countries, is regarded as one of the most hit by food insecurity, poverty, and natural catastrophes (Gera, 2004). Approximately two-thirds of Pakistan's population lives in rural regions and is directly or indirectly dependent on the agricultural industry for food and income (FAO, 2009). However, the majority of rural households possess less than two hectares of land and have inadequate access to services and resources (Abid et al., 2011). However, the majority of rural households possess less than two hectares of land and have limited access to services and resources (Bashir et al., 2012). Furthermore, Pakistan's inadequate adaptive capacity to manage environmental calamities has a harmful impact on AgGDP and local food security (Abid et al., 2011). Therefore, this study investigates the effect of energy cost on agricultural production in the case of Pakistan.

Since Kraft and Kraft (1978) pioneering study, the link between energy use and economic development has been a hot subject. Most empirical findings show that EC and AgGDP are positively related (Eggoh et al., 2011; Gozgor et al., 2018; Koondhar et al., 2021; Odhiambo, 2009; Tang et al., 2016; Zhixin and Xin, 2011). However, as the national economy has grown rapidly, energy shortages and environmental degradation have posed hurdles to its long-term growth. Furthermore, energy consumption has been shown to be a link between economic progress and a sustainable environment (Mirza and Kanwal, 2017). However, research indicates a limited association between renewable energy usage and economic development (Chen et al., 2020b; Razmi et al., 2020; Wang et al., 2022). Other researchers have proposed four basic hypotheses for the causal links between renewable energy usage and economic development (Boukhelkhal, 2022; Das et al., 2022). First, the growth hypothesis suggests that increasing renewable energy use will result in longer-term economic growth (Chikezie Ekwueme et al., 2022; Li et al., 2022). Second, conservative assumptions show that increased economic development can boost renewable energy use (El-Karimi and El-houjjaji, 2022; Ning et al., 2023). Studies provide evidence for the feedback hypothesis, which is based on a two-way causal relationship between renewable energy usage and economic development (Akram et al., 2021; Salari et al., 2021). The neutral hypothesis proposes an independent relationship between renewable energy usage and AgGDP (Cevik et al., 2020; Destek and Aslan, 2017). Results based on these assumptions vary depending on the technique utilized, the energy dimension, the location, and the income grouping countries (Zhang et al., 2023).

Koondhar et al. (2021) explored the asymmetric causation of agri-CO2, EC, FRC, and AgGDP in Pakistan, and data from 1976 to 2018 were utilized to estimate the NARDL model. They found that there is are causal relationship running from EC and FRC to AgGDP. Furthermore, the unidirectional causation that links fertilizer usage to cereal food output. Furthermore, the findings of the NARDL model show that changes in agri-CO2, EC, and FRC lead to variations in grain output. The dynamic multiplier curve indicates that shocks affect cereal food output. They also indicate that Pakistani farmers must transition from chemical FRC and non-renewable EC to organic FRC and renewable-EC in order to minimize carbon emissions and enhance AgGDP while maintaining a healthy environment. Abbasi et al. (2021) used VECM to predict AgElec in Pakistan from 1970 to 2018 to determine the link between EC, price, and real GDP. The total impact of an unanticipated shock on each variable is decomposed using the Dynamic Variance Decomposition Technique. They demonstrate that the components are co-integrated. Their findings also reveal the long-term link between EC, price, and RGDP in the industrial sector.

The study's key motives are, first, that decreasing expenses on farms is a top priority for various stakeholders, particularly farmers. The primary motivation behind this study is the need to reduce farming expenses, which is a top priority for many stakeholders, especially farmers. Lowering energy costs can lead to two significant outcomes: an increase in net farm income and positive environmental impacts, supporting more sustainable agriculture and rural development. In consequence, the agriculture industry may be a viable source of renewable and clean energy. Second, agricultural output is heavily dependent on the cost of energy necessary for cultivation.

METHODOLOGY

This research is quantitative in nature and used data from 1973 to 2022 in the case of Pakistan to investigate the effect of energy cost on agricultural production.

Model Specification

This model is used to check the influence of the energy cost on agricultural output in Pakistan. This study used the Agriculture, forestry, and fishing, value added (% of GDP) as a proxy for agricultural production is also used by Zhang et al. (2019) and Chandio et al. (2020), and used gas, oil, and electricity consumption as independent variables. The variables gas, oil, and electricity consumption are also used by Chandio et al. (2020), Coal, oil, gas, petroleum products, and electricity by Gohin and Chantret (2010), and agriculture energy consumption by Saudi et al. (2019) and Zhang et al. (2019) to represent the energy cost. This study used labor force participation which were also used by Sands et al. (2011), and Chen et al. (2020a), Agricultural land (% of land area) also used by Chen et al. (2020a), and Agricultural machinery, tractors per 100 sq. km of arable land also used by Chen et al. (2020a), water availability also used by Memon et al. (2015), net food export also used by Kohansal (2010) and Gilani (2015) and fertilizer consumption also used by Stewart et al. (2005) and Memon et al. (2015), as independent variables. Therefore, this study used the following adapted model, which is also used by Zhang et al. (2019) and Chandio et al. (2020).

$$AgGDP_t = \beta_0 + \beta_1 AgL_t + \beta_2 AgM_t + \beta_3 LFP_t + \beta_4 AgOil_t + \beta_5 AgGas_t + \beta_6 AgElec_t + \beta_7 WA_t + \beta_8 NFX_t + \beta_9 FRC_t + \mu_t \quad (1)$$

Where,

$AgGDP_t$: Agriculture, forestry, and fishing, value added (% of GDP)

AgL_t: Agricultural land (% of land area)

AgM_t: Agri machinery, tractors per 100 sq. km of arable land

LFP_t: Participation rate of Labor force, total (% of total population ages 15+)

$AgOil_t$: Agriculture sector consumption of oil/petroleum (tons)

$AgGas_t$: Agriculture sector consumption of gas (mm cft)

$AgElec_t$: Agriculture sector consumption of electricity (GWh)

WA_t: Water availability (MAF)

NFX_t: Net Food Exports (% of merchandise)

FRC_t: Fertilizer consumption (% of fertilizer production)

As per the data behavior, because of the mixed order of integration, this study recommended the use of ARDL techniques and the Granger Causality test for estimation.

RESULTS AND DISCUSSIONS

Unit Root Test Results

Table 1 presents the ADF and PP tests results, which shows that agricultural production, food inflation, energy inflation, agricultural land, labor force participation, and water availability are stationary at level and have zero degree order of integration (1(0)), while the rest of variables are stationary at 1st difference and have 1st degree order of integration (1(1)). The order of integration of the variables is mixed; therefore, the data behavior of this study recommends the use of ARDL techniques for estimation.

Regression Results: The Effect of Energy Cost on Agricultural Production

Table 2 presents the ARDL results of the effect of the energy cost on agricultural production. In the long run (later on LR), the agricultural land has an optimistic and significant consequence on agricultural production. Which means that a percent increase in the agricultural land, on average, leads to a rise the agricultural production by 0.25%. According to Shmatkovska et al. (2020) that agricultural land has a positive and significant effect the agricultural production in Ukraine. Similarly, Liu et al. (2020) stated that a % upsurge in the agricultural land will upsurge will increase the agricultural output by 0.60% in Asian Countries. Similarly, the agricultural machinery has an optimistic and noteworthy effect on AgGDP. Which means that a percent increase in the agricultural machinery, on average, leads to a rise in the agricultural production by 0.02%. Ojiya et al. (2017) confirmed the link between agricultural machinery and output. Furthermore, Meng et al. (2024) estimate a Trans-log model using a panel dataset of 126 counties in China's Xinjiang and Hubei provinces from 2002-2012. Though they discovered that the overall elasticity of output with regard to equipment inputs is 0.03, the capacity structure of AgM may influence AgGDP by causing the reallocation of other input components. Along with the upsizing of agricultural machines, they observe that the complementarity between AgM horsepower and land inputs in productivity grows, but the combined effect of AgM and FRC decline.

Similarly, the labor force participation has an optimistic and noteworthy effect on agricultural production. Which means that a percent increase in the agricultural land, on average, leads to a rise the agricultural production by 0.03%. The past literature discussed the labor force in agricultural productivity. Therefore, human capital is critical to all businesses, including agriculture (Kim and Moon, 2018). The efficiency of the workforce on any particular farm has the potential to boost agricultural output. Farmers in the US are well-trained to work effectively, which is critical to their high performance (Mehmood and Hanaysha, 2022). China's agricultural productivity is dependent on the quality of its LFP, which grows when workers work from the heart (Hutahayan, 2020). The cash given by investors is critical to the farm workforce. The workforce's high pay encourages them to perform well in AgGDP, influencing the country's economic success (Uduji et al., 2021). According to Chrismanto et al. (2019), the agriculture sector has a big influence on sustainability, but it requires investment in the labor force to produce. Similarly, Guo et al. (2015) demonstrate that, in the context of aging, fluctuations in working-age families have a major influence on agricultural productivity.

Table 1. ADF test results.

Variables	ADF test (p-value)		Decision
	At Level	1st Dif	
$AgGDP_t$	-3.0111** (0.0408)	----	Stationary at level
AgL_t	-5.4198* (0.0000)	----	Stationary at level
AgM_t	-1.8060 (0.3734)	-5.9044* (0.0000)	Stationary at 1st difference
LFP_t	-6.6289* (0.0000)	----	Stationary at level
$AgOil_t$	1.0259 (0.9963)	-6.4395* (0.0000)	Stationary at 1st difference
$AgGas_t$	-2.0219 (0.2768)	-6.8894* (0.0000)	Stationary at 1st difference
$AgElec_t$	-2.8044*** (0.0652)	-6.1655* (0.0000)	Stationary at 1st difference
WA_t	-3.1575** (0.0289)	----	Stationary at level
NFX_t	-2.0672 (0.2584)	-9.5351* (0.0000)	Stationary at 1st difference
FRC_t	-2.0048 (0.2839)	-4.8304* (0.0003)	Stationary at 1st difference

Note: *,** and *** depicted the consequence level at 1.0%, 5.0% and 10.0% respectively.

Similarly, the AgOil has a positive and noteworthy effect on agricultural production. Which means that a % upsurge in the consumption of Oil in the agricultural sector, on average, leads to a rise the agricultural production by 0.76%. Similarly, the gas consumption has a positive and noteworthy effect on agricultural production. Which means that a percent increase in the consumption of gas in the agricultural sector, on average, leads to a rise the agricultural production by 0.82%. Similarly, the electricity consumption has a positive and noteworthy effect on agricultural production. Which means that a percent increase in the consumption of electricity in the agricultural sector, on average, leads to a rise the agricultural production by 0.93%. Bekhet and Abdullah (2010) discovered that the agri-sector relies more on inputs from the petroleum and coal sectors than crude oil, natural gas, and coal. Similarly, Popoola et al. (2022) discovered that the CPI, oil output, and oil exports had a favorable influence on agricultural productivity in Nigeria. Similarly, Moghaddasi and Pour (2016) found that the EC has an optimistic effect on agricultural productivity in Iran. Similarly, Karkacier et al. (2006) found a substantial link between energy usage and AgGDP in Turkey. Furthermore, according to Faridi and Murtaza (2013), gas and oil consumption have a noteworthy impact on GDP and agricultural production in Pakistan.

Similarly, the water availability has an optimistic and noteworthy effect on AgGDP. This means that a % upsurge in the WA, on average, leads to a rise the agricultural production by 0.38%. Like, Rehman et al. (2019) discovered that FRC, enhanced seed, and credit distribution all had an optimistic and substantial impact on AgGDP, whereas WA had an adverse but negligible impact in Pakistan. Moreover, Mendelsohn and Dinar (2003) confirmed that water availability is too important for agricultural production.

Table 2. ARDL results for the effect of energy cost on agricultural production.

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
Long Run Coefficient				
AgL_t	0.2537*	0.0697	3.6402	0.0009
AgM_t	0.0157***	0.0079	1.9826	0.0558
LFP_t	0.0248*	0.0086	2.8807	0.0069
$AgOil_t$	0.7567**	0.3490	2.1683	0.0374
$AgGas_t$	0.8190**	0.3169	2.5845	0.0144
$AgElec_t$	0.9337***	0.4845	1.9272	0.0626
WA_t	0.3774*	0.1087	3.4716	0.0015
NFX_t	0.0555*	0.0117	4.7333	0.0000
FRC_t	0.0101**	0.0048	2.0913	0.0443
C	-10.8089	11.5051	-0.9395	0.3543
Bound Test		F-Statistics	3.3545**	
Short Run Coefficient				
$D(AgL_t)$	0.0441	0.0461	0.9561	0.3452
$D(AgM_t)$	0.0189	0.0162	1.1714	0.2489
$D(LFP_t)$	0.0276*	0.0088	3.1285	0.0034
$D(AgOil_t)$	0.0204	0.3403	0.0599	0.9526
$D(AgGas_t)$	0.4482	0.5415	0.8276	0.4132
$D(AgElec_t)$	0.3673	0.7986	0.4599	0.6483
$D(WA_t)$	0.1936**	0.0919	2.1059	0.0421
$D(NFX_t)$	0.0039	0.0351	0.1113	0.9119
$D(FRC_t)$	0.0128*	0.0031	4.1539	0.0002
ECM_{t-1}	-0.4015*	0.0634	-6.3300	0.0000
C	-0.1519	0.1476	-1.0292	0.3101
Diagnostic Tests Results				
B.P.G Hetroskedasticity test Result				
H_0 = Homoskedasticity		F-Statistic	0.3036	0.5867
Ramsey RESET Test		t-Statistic	0.6971	0.4925
H_0=No Specification Error in the model.		F-Statistic	0.4859	0.4925
B.G Serial Correlation LM Test				
H_0=No Serial Correlation.		F-Statistic	0.8726	0.6242

Note: *,** and *** depicted the consequence level at 1.0%, 5.0% and 10.0% respectively and the critical values for the bound test is 2.04-2.08 for 5%.

Similarly, the net food exports have an optimistic and noteworthy effect on AgGDP. Which means that a percent increase in the net food exports, on average, leads to a rise in the agricultural production by 0.06%. Gilani (2015) concludes that agricultural exports have an influence on agricultural production, or that as exports grow, so does agricultural productivity. Similarly, Hassine et al. (2010) demonstrated that the initial opening of international trade enhances GDP and reduces poverty by 11.0% under the agri-trade liberalization program. However, Mustafa et al. (2001) stated that when there is a lower tariff on exporting agricultural commodities from developing countries, because of technological advancements, developed countries can produce those same commodities more cheaply in emerging countries, which has a direct consequence on domestic-demand in those countries, and then imports begin to rise and exports may fall, resulting in declines in agricultural commodities. Similarly, the fertilizer has an optimistic and noteworthy effect on AgGDP. Which means that a percent increase in the fertilizer, on average, leads to a rise the agricultural production by 0.01%. Like Afzal and Ahmad (2009) demonstrate that steady fertilization increases crop yields and agricultural profitability. Furthermore, nutrient deficits act as a cure, helping to preserve soil fertility. Crop yields cannot be boosted without fertilizer. However, Patra et al. (2016) found that increased usage of chemical-FRC had no significant association with increased agricultural productivity and yield.

Furthermore, in the Short run (later on SR), the agri-land has an inconsequential effect on AgGDP. Similarly, the agri machinery also has an inconsequential effect on AgGDP. However, the labor force participation has an optimistic and noteworthy effect on agricultural production. This means that a % upsurge in the labor force participation, on average, leads to a rise the agricultural production by 0.03%. Similarly, the AgOil has an optimistic but inconsequential effect on AgGDP. Correspondingly, the AgGas has an optimistic but insignificant effect on AgGDP. Correspondingly, the AgElec has an optimistic but inconsequential effect on AgGDP. However, the water availability has an optimistic and noteworthy effect on AgGDP. This means that a % upsurge in the WA, on average, leads to a rise the agricultural output by 0.19%. Similarly, the net food exports have an insignificant effect on agricultural production. However, the FRC has a positive and noteworthy effect on agricultural production. Which means that a percent increase in the consumption of fertilizer in the agricultural sector, on average, leads to a rise the agricultural production by 0.01%.

Moreover, the ARDL bound test indicated that there is exist the LR co-integration exists among the variables. Furthermore, the speed of adjustment from the SR to LR equilibrium is 40%. Moreover, the diagnostic test results show that there is no heteroskedasticity, autocorrelation, and specification error in the model.

Normality Test Results

Figure 1 depicts the JB test outputs, which show that the residuals are normally distributed.

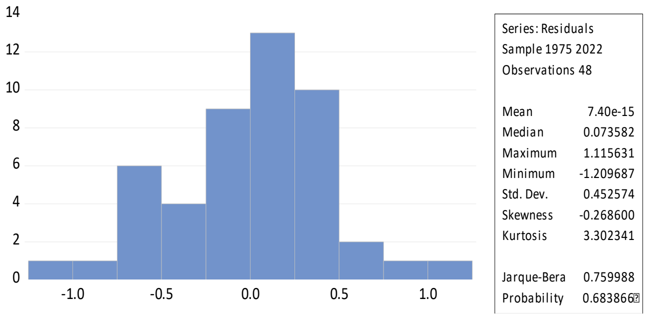

Figure 1. JB test results.

Stability Test Results

Figure 2 depicts the stability test outputs, which show that the model is stable.

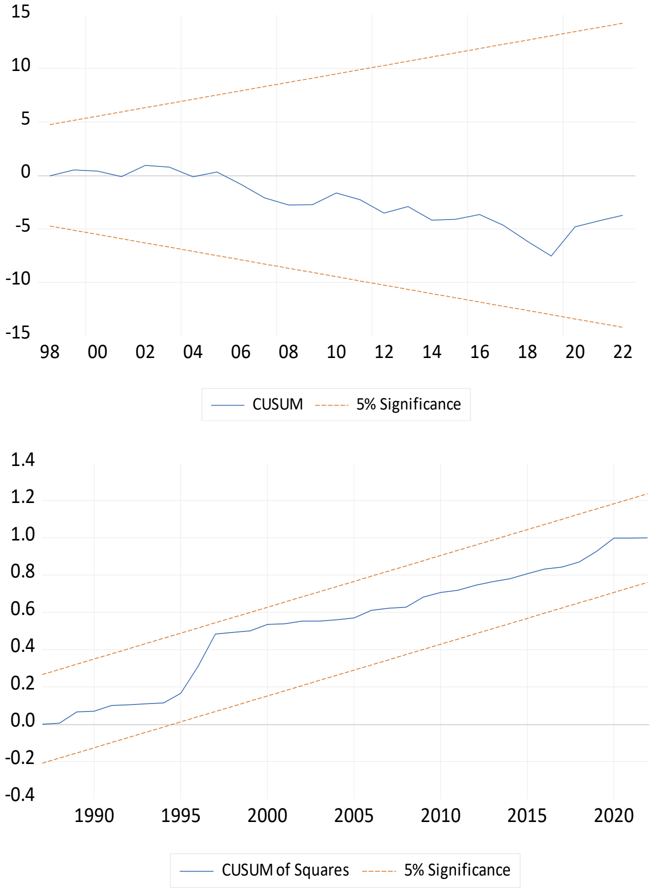

Figure 2. CUSUM and CUSUMSQ test results.

CONCLUSIONS AND RECOMMENDATIONS

Pakistan, like many other developing countries, is regarded as one of the most hit by food insecurity, poverty, and natural catastrophes. Approximately two-thirds of Pakistan's population live in rural regions and are directly or indirectly dependent on the agricultural industry for food and income. Furthermore, Pakistan's inadequate adaptive capacity to manage environmental calamities has a negative influence on AgGDP and local FS. Because agriculture, like other industries, has become more reliant on energy sources. Therefore, the links between AgEC, AgGDP, and energy-resource restrictions are intricate. Furthermore, continuous variations in food-production and consumption practices that coincide with globalization, urbanization, and demographic shifts highlight the relevance of energy usage in food systems as an FS issue. Therefore, this study investigates the effect of energy cost on agricultural production in the case of Pakistan. To achieve the above objectives, this study used the data from 1973 to 2022 in case of Pakistan, which was collected from World Development Indicators (2024) and employed ARDL and other diagnostic tests to estimate the model. This study found that in the LR, the AgL, machinery, labor force participation, petrol/oil, gas, and electricity consumption in the agricultural sector, and water availability have positive consequences on AgGDP. Moreover, the agricultural land and machinery, and oil, gas, and electricity consumption and net food export have no effect on agricultural production. However, the labor force participation, water availability, and FRC have a positive effect on agricultural production. This study concluded that energy cost has a positive effect on agricultural productivity.

The government is required to strengthen administrative control, reform the subsidies system, reform the agricultural sector, use renewable energy instead of non-renewable energy, and stop the political interference in the monetary policy. This study suggested reducing the electricity prices to develop the local industry, especially for the agricultural sector, to enhance growth. The government develops a strong governance structure for the distribution of energy resources. As the economy of Pakistan is based on the agricultural sector, therefore, the government needs to provide subsidies on energy resources to enhance the agricultural sector.

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