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Energy Consumption, Agricultural and Industrial Sector Productivity Nexus: Evidence from Pakistan

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Abstract: Both agricultural and industrial sectors play a significant role in economic development of Pakistan. Both the sectors promote employment opportunities, provide food, and earn foreign exchange. However, energy shortage and energy price hike are the major problems which adversely affect the performance of both agricultural and industrial sector. This study attempts to examine the impact of energy consumption on the industrial and agricultural sectors' productivities through the channel of change in energy price in Pakistan. The study also investigates the interdependence of industrial and agricultural sectors. Using simultaneous equations model, the results GMM reveal that increase in energy prices reduce agricultural and industrial sector productivity via decrease in energy consumption. Results also depict a strong positive interdependence of both the sectors, which means that these sectors push and pull each other. Keeping in view the negative impact of energy price on the agricultural and industrial sectors productivities and the mutual interdependence in the productivities of both the sectors, this study suggest sensuring smooth and consistent supply of energy to these sectors with stable prices.
Key Words: Energy Price, Energy Consumption, Industrial and Agricultural Productivity

1. Introduction

Development of any economy strongly related to its economic growth which, in turn, depends on the sectorial growth of different sectors. Productive sectors reinforce each other and significantly contribute to the overall economic growth of a country. Agriculture and industrial sectors are two major interdependent sectors which significantly contribute to economic growth of a country. Agricultural production requires the industrial products like machinery, fertilizers, pesticides, croppers, mechanical tools like motors, and pumps. Industrial sector develops new technologies, and designs equipment and instruments through research and development. In this way, the agricultural sector growth and development depends on the growth and development of industrial sector. Similarly, agricultural sector

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provides raw material to the industrial sector[4] for further processing and production of finished goods. For example, raw cotton, sugar cane and wood provided to the textile, sugar and sports industries respectively. Thus development in agricultural sector leads to a development in industrial sector.

Agriculture has been an important sector in Pakistan. It the time of independence its share in GDP was about 50 percent. However, with the passage of time, this proportion has decreased. Agriculture is the second largest component of GDP of Pakistan (22.04% by 2019). It is the major source of food provision and employment. Its share in total employment is 36.66 percent. Agricultural sector is also the major source of earning foreign exchange and its share in total export earning is approximately 60 percent. Despite this, industrial sector plays more vital role in the economic development of a country. The developed nations not only developed their industrial sectors but also transferred technological changes into their agricultural sectors which brought revolution in agricultural production through mechanization. Industrial sector also provides employment to the population and promotes exports. The contribution of industrial sector in GDP of Pakistan is 18.34 percent and its share in total employment is 25.33 percent in 2019. Industrial sector produces variety of commodities which causes a decrease in reliance on imported goods and thus save foreign exchange.

Although both agricultural and industrial sectors play a significant role in economic development of Pakistan but their performance is low due to number of factors. Among these, energy shortage and energy price hike are the major problems which deteriorate performance of both agricultural and industrial sector. Energy is an important input of production. Agricultural sector uses energy for running tube wells, tractors, and other farms machinery. On the other hand, industrial sector requires energy for running motor engines and other machines. Shortage of energy causes stagnation of the industrial sector and raises the cost of production, which leads to increase the prices of finished goods. Domestic consumers have to suffer due to this increase in prices. As a result, demand for goods decreases which in turn affect the productions of both industrial and agricultural sectors. Price competitiveness reduces exports in the international market and thereby causes reduction in the foreign exchange earnings. In this way the expensive supply of energy and its shortages result in production loss. As a result of these reasons, most of industries are either shutting down or shifting to the neighbor countries.

Though numbers of studies have examined the impact of energy crises on the economy of Pakistan but none of the study incorporates agricultural and industrial productivity simultaneously. As both the sectors are interdependent and significantly influence the performance of each other, therefore examining the performance of any sector separately does not make any sense. This study is the first in this regard that examines the inter-sectorial impacts of agricultural and industrial sector productivities. Further this study also examines the impact of energy consumption and energy prices on the productivities of both agricultural and industrial sectors. The specific objectives of the study are

1. to examine the impact of energy prices on energy consumption
2. to examine the impact of energy consumption on agricultural and industrial sector productivity..
3. to investigate the inter-sectorial dependence of agricultural and industrial sectors.

The rest of the paper is structured as follows. Section 2 summarizes past research on interdependence of industrial and agricultural sectors, and impact of energy price on output. Section 3 presents theoretical framework, empirical model, construction of variables and estimation methodology. Section 4 presents results and their discussion, while section 5 concludes the study.

[4] Raw cotton, sugar cane and wood provided to the textile, sugar and sports industries respectively

2. Review of Literature

A number of studies have been carried out to investigate the interrelationship between agricultural and industrial sector and reach to mixed results. Rosenstein-Rodan (1943), Lewis (1954), and Ranis and Fei (1961) find positive role of agricultural sector which provides raw materials, food, and fiber etc. to industrial sector. Chenery and Keesing(1979) and Kuznets (1965) argue that economic development is the result of structural transformation in agriculture sector that enhance industrial sector activities in turn. Matahir, (2012) shows the existence of long-run co-integrating relationship between agricultural and industrial sectors in Malaysia.Hye (2009), Subramaniam and Reed (2009),and Onakoya (2013) find a positive relationship between agriculture and industrial sectors in case of Pakistan, Poland and Romania, and Nigeria, respectively. Yao (1996) for China shows a positive impact of agriculture sector on industrial sector and a negative impact of the industrial sector on agricultural sector. However, Koo and Lou (1997) in China show a positive contribution of industrial growth in agricultural growth, but the reverse is not found. Katircioglu, (2006) for North Cyprus explores that agricultural sector is the main contributor in the growth of industrial and services sectors in the long run. Findings by Kaur*et al.* (2009) for India reveal a strong inter-sectorial linkage between manufacturing sector, services and agricultural in the long run.

As energy is an important input used in the production process, therefore rises in its price has sector-wide serious concern. A number of studies have examined the impact of energy prices on various sectors of the economy[5]. Increase in energy price makes energy input costly. Demand for energy reduces and thereby negatively affect the output of different sector.

There also exists an ample research on the relationship between different types of energy and output level. Among these, Mushtaq*et al.* (2007) finds for Pakistan a unidirectional causality running from per capita real GDP to oil consumption, a unidirectional causality running from electricity consumption to per capita real GDP and no causal relationship between gas consumption and per capita real GDP. The results also reveal that increase in growth rate of agricultural sector increases oil demand. Soytasand Sari (2007) explore a long run relationship between electricity consumption and Turkish manufacturing sector output. The results depict a unidirectional causality that run from electricity consumption to the manufacturing value added in the long run. Nwosaand Temidayo, (2012) examine the link between energy consumption and sectorial production of Nigeria and reveals a unidirectional causal relationship between energy consumption and agricultural production and between services sector and energy consumption.

Qaziand Yulin (2013) investigate the relationship between energy input, prices and industrial output in Pakistan and find positive impact of energy consumption on industrial output. Mirza*et al* (2014) reveal positive impact of electricity consumption on both industrial and service sector output for Pakistan. Further, the study also finds a negative impact of electricity price on industrial output and services sector. Chandio*et al.* (2018) investigate the relationship between energy consumption and agricultural sector growth in Pakistan and find positive impacts of gas consumption and electricity consumption on agricultural output growth both in the short run and long run. Unlike the common belief and findings, Abokyi*et al.* (2018) show a negative impact of electricity consumption on output of manufacturing sector of Ghana.

[5]Amongthese Binuomote and Odeniyi (2013) andIkram and Waqas (2014) investigate the impact of crude oil prices on the agricultural productivity for Nigeria and Pakistan respectively. Wang and McPhail, (2012) examine the impact of energy shocks on agricultural productivity growth and food prices of US. Bolaji and Bolaji, (2010) report the impact of oil prices on manufacturing companies in Nigeria. Eksi et al (2011) show the relationship between oil prices and industrial production in OECD countries.

Researchers have also examined the impact of energy prices on the agricultural and industrial sector productivity. Among these, Linn (2006) finds a negative impact of oil prices on the production of manufacturing sector in US. Jimenez (2008) reveals that oil price shock negatively affect the output of manufacturing sector. Twimukye and Matovu (2009) finds that rise in the oil prices significantly reduce the agricultural and manufacturing sectors output of Uganda. Eksi*et al.* (2011) indicate that oil prices have negative impact on industrial output of OECD countries. Binuomote and Odeniyi (2013) show that world crude oil price negatively affect agricultural sector productivity of Nigeria. Ikramand Waqas (2014) show a negative effect of oil prices on the agricultural sector productivity of Pakistan.

3. Theoretical Framework and Empirical Model

Interlink between agricultural and industrial sector has been a long debated issue in economic literature. Both the sectors depend on each other in respect to their demand and supply of products. Agricultural production needs the industrial goods while industrial sector needs agricultural products. The supply side linkage arises due to the interdependence of the sectors for meeting the needs of their productive inputs, whereas the demand side linkages fulfill the final consumption. The linkages may be further categorized into (1) backward linkage which identifies the dependence of a sector on others for their input supplies[6] and (2) forward linkage which identifies how the sector distributes its output to the remaining economy[7].

Agricultural researchers introduce better quality seeds with high yield, resistant to pets and disease, and suited for local condition. However, it is the industrial sector which provides new technologies, and design equipment and instruments necessary to carry out research. Industrial sector also provides chemical fertilizers to enhance productivity and increase production of agriculture sector. Industrial sector provides bricks, iron cement to build wells, storage reservoirs, dams, canals, and tube wells for irrigation of the crops. Apparatuses such as motors, and pump sets etc. are also provided by the industrial sector. To save crops from pets and diseases the industrial sector provides pesticides and helps in raising agricultural production. Tractor, Harvester, and Machines etc. are also provided by the industrial sector for cultivation. Further, industry also helps farmers in building warehouses for storing their products till they get fair market price.

On the other hand, labor demand in agricultural sector reduces due to the use of advance technologies and the surplus labor is released to the industrial sector. The agricultural sector also provides raw materials to the industrial sector for the production of finished goods. For example, wood, sugar cane, and raw cotton are provided to the sports, textile, and sugar industries, respectively. It also provides crops to rice mills, flour mills, and many others. Further, development of the agricultural sector improves the living standard of the farmers by raising their income. As a result demand for building of better houses and luxurious goods such as television, computer, automobiles etc. by the farmers increases which, in turn, causes growth in the particular industries.

Based on above discussion, we develop a model which simultaneously relates agricultural sector productivity, industrial sector productivity, energy consumption in agriculture sector and energy consumption in industrial sector. In our model, energy price does not directly affect industrial and agricultural sector productivities; rather it first influences energy demand which in turn influences industrial and agricultural sector productivity. Apart from energy prices, energy consumptions by agricultural and industrial sectors are also influenced by the productivities of these sectors. Mathematically:

$$PA_t = f(PA_{t-1}, PI_t,\ ECA_t,\ FC_t) \quad (1)$$

[6] For example agriculture sector uses industrial inputs like fertilizers, pesticides, machine tools

[7] For example agricultural sector supplies raw materials to agro-based industries.

$$PI_t = g(PI_{t-1}, PA_t, ECI_t, OP_t) \quad (2)$$

$$ECA_t = h(ECA_{t-1}, PA_t, EP_t) \quad (3)$$

$$ECI_t = k(ECI_{t-1}, PI_t, EP_t) \quad (4)$$

Equation (1) shows that agricultural sector productivity (PA_t) depends on the industrial sector productivity (PI_t), energy consumption in agricultural sector (ECA_t), fertilizer consumption (FC_t), and on its ownlag value (PA_{t-1}). Equation (2) depicts that industrial sector productivity depends on the agricultural sector productivity, energy consumption in industrial sector (ECI_t), trade openness (OP_t), and on its own lag value (PI_{t-1}). Equation (3) represents that energy consumption in agricultural sector depends on agricultural sector productivity, energy price index (EP_t)and on its own past value (ECA_{t-1}). Similarly equation (4) shows that energy consumption in industrial sector (ECI_t) depends on industrial sector productivity (PI_t), energy price (EP_t)and on its own past value (ECI_{t-1}).

In stochastic form, above system of equations can be written as:

$$PA_t = \alpha_0 + \alpha_1 PI_t + \alpha_2 ECA_t + \alpha_3 FC_t + \alpha_4 PA_{t-1} + e_t \quad (5)$$

$$PI_t = \beta_0 + \beta_1 PA_t + \beta_2 ECI_t + \beta_3 OP_t + \beta_4 PI_{t-1} + u_t \quad (6)$$

$$ECA_t = \gamma_0 + \gamma_1 PA_t + \gamma_2 EP_t + \gamma_3 ECA_{t-1} + v_t \quad (7)$$

$$ECI_t = \delta_0 + \delta_1 PI_t + \delta_2 EP_t + \delta_3 ECI_{t-1} + \varepsilon_t \quad (8)$$

where e_t, u_t, $v_t$and ε_t are stochastic error terms.

To empirically estimate above model, we first construct variables used in our model. The details of the variables are given below:

Agricultural and industrial sector productivities are computed by using following procedures:

For both agricultural and industrial sector output (Y_t) we consider value added at constant price and assume a constant return to scale Cobb-Douglas production function as:

$$Y_t = AL_t^{\alpha} K_t^{1-\alpha} \quad (9)$$

Labor input (L_t) is taken in million. Capital stock at time "t" (K_t) is computed by following Hamid and Pichler (2009) as:

$$\mathrm{K_t} = (1-\delta) * \mathrm{K_{t-1}} + \mathrm{I_t} \quad (10)$$

Where "K" denotes capital stock, "t' represents time, ""δ" is rate of depreciation[8] and $\mathrm{I_t}$ is the investment. For both agricultural and industrial sector, total factor productivities are computed as:

$$PA = \frac{Y_A}{L_A^{\alpha} K_A^{1-\alpha}} \quad (11)$$

$$PI = \frac{Y_I}{L_I^{\alpha} K_I^{1-\alpha}} \quad (12)$$

Where (PA) is agricultural sector productivity, Y_A is agricultural output, L_A and K_A are the total labor and capital inputs, respectively, employed in agriculture sector. PI, Y_I, L_I and K_I are industrial sector productivity,industrial output, total labor, and capital inputs employed in industrial sector, respectively[9].

Energy consumption in a particular sector is the sum of three types of energy; (1) electricity (2) natural gas and (3) petroleum products. Following Siddiqui (2004), we convert the energy consumption into common unit - in tons of oil equivalent (TOE) as follow:

$$TOE = 1\ GWH * 86.04 \quad (13)$$

$$TOE = 1\ MMCFT\ *\ 25.1996 \quad (14)$$

Whereon eGWH- Giga Watt Hour (unit of electricity) and one $MMCFT$- million cubic feet (unit of natural gas)are equivalent to 86.04 TOE[10] (unit of petroleum product) and 25.1996 TOE[11] respectively.

[8]We assume constant depreciation rate of 5%.

[9]Value of α is assumed to be equal to 0.7 based on past empirical results.

[10]http://www.traditionaloven.com/tutorials/energy/convert giga watt hour gwh to ton oil equivalent toe.html

After converting all energy sources in to same unit we then simply add them for both the sectors which gives us sector specific consumption of energy. For **Energy Prices** we use energy price index.

Fertilizers are the agrochemical products which are used as an input in the agricultural production (Nadeem*et al* 2010). Fertilizer consumption is measured in million kilograms. ***Trade openness*** is the ratio of exports plus imports to gross domestic product (GDP). Harrison (1996),Ilyas*et al* (2010) and Shahbaz*et al* (2008) also use trade openness variables and measure it as follow:

$$TO = \frac{(\text{exports+Imports})}{\text{Gross Domestic Product}} \quad (15)$$

All the three variables; exports, imports and GDP are measured in Million US Dollars.

Data spanning from 1972 to 2014 is utilized for Pakistan in our study which is taken from GOP, Pakistan Economic Survey (various issues), Labor Force Survey (various issues), Statistical Year Book and World Development Indicator (WDI).

4. Results and Discussion

To examine the impact of energy prices on the agricultural and industrial sector productivity, we estimate simultaneous equation model involving four interdependent equations. Keeping in view, the interdependency of the equations, we employ instrumental variable technique -Generalized Method of Moments (GMM) to equation (5) through (8) simultaneously[12].Results are summarized in Table 4.1.

Table 4.1: GMM Estimates

Dependent Variable: Agricultural Sector Productivity				
Intercept	***lnPI$_t$***	***lnECA$_t$***	***lnFC$_t$***	***lnPA$_{t-1}$***
0.0419 (0.1546)	0.888*** (0.052)	0.257* (0.137)	-0.055 (0.038)	0.614*** (0.123)
R^2= 0.98		D.W=1.98		
Dependent Variable: Industrial Sector Productivity				
Intercept	***lnPA$_t$***	***lnECI$_t$***	***lnPI$_{t-1}$***	***lnTO$_t$***
-0.504*** (0.134)	0.126* (0.0667)	0.329*** (0.074)	0.529*** (0.0795)	-0.034 (0.10)
R^2= 0.99		D.W=1.65		
Dependent Variable: Energy Consumption in Agricultural Sector				
Intercept	lnPA$_t$	lnEP$_t$	lnECA$_{t-1}$	
-0.5783** (0.274)	0.565*** (0.143)	-0.0257** (0.011)	0.529*** (0.075)	
R^2= 0.98		D.W=1.84		
Dependent Variable: Energy Consumption in Industrial Sector				
Intercept	lnPI$_t$	lnEP$_t$	lnECI$_{t-1}$	
-0.096 (0.162)	0.570*** (0.169)	-0.0403*** (0.014)	0.635*** (0.097)	
R^2= 0.98		D.W=1.97		

[11]http://www.kylesconverter.com/energy, work, and heat/cubic feet of natural gas to tons of oil equivalent

[12]Before applying GMM we checked the time series properties of the variables. All the variables are integrated of order 1 and are co-integrated.

Note:*** 1% level of significance, **5% level of significance and *10% level of significance. In parenthesis are standard errors and ln stands for natural log.

Results give in Table 4.1 show a positive impact of industrial sector productivity on agricultural sector productivity. This is consistent with the argument of neo-classical theory which postulates that agriculture sector benefits from the spillover effect of higher productivity in the industrial sector. Industrial development plays a significant role in making agricultural sector more efficient through advance technologies. These findings are in line with Hye (2009) for Pakistan who shows interdependence of agricultural and industrial. Similarly, our results are also consistent with the Subramanian and Reed (2009) for Poland and Romania, and Onakoya and Babatunde (2013) for Nigeria who also report positive impact of manufacturing sector production on agricultural sector production. Further, results also show a positive impact of energy consumption on the agricultural sector productivity. It is because different agricultural machineries like tractors, tube wells etc. use energy. The use of energy in agricultural sector indirectly means increase in the use of modern machineries which in turn increases agricultural sector production. Fertilizer variable carries out an unexpected insignificant negative sign. One of the possible reasons may be the excess use of fertilizers which affects agricultural sector productivity negatively. This result is in line with Ikram and Waqas (2014).

Findings also reveal that agricultural productivity has positive impact on industrial sector productivity. It is due to the fact that increase in agriculture sector productivity leads to increase the supply of raw material to the industrial sector and thus helps in increasing industrial productivity. The impact of energy consumption on industrial sector productivity is positive. Our results are in line with Qazi and Yulin (2013) who find similar positive impact of energy consumption (oil, coal, gas and electricity) on industrial output of Pakistan. Similarly Mirza*et al.* (2014) and Jamil and Ahmad (2010) also show a positive impact of energy(electricity) consumption on industrial output. This shows that if energy consumption in industrial sector increases the industrial productivity will also increase and vice versa. Different type of energies like natural gas, petroleum products, and electricity are used in the industrial sector. The down turn in the industrial sector of Pakistan is due to shortage of energy sources. If adequate supply of energy is provided to the industrial sector it will raise industrial sector production. Results also depict a negative impact, though insignificant, of trade openness on the industrial sector productivity. Similar result for trade openness is found by Ilyas*et al.*(2010)and .One of the possible reasons of the insignificant impact of the trade openness might be the inability of Pakistan to produce such type of goods to compete with the emerging markets like China and India.

Table 4.1 also reports the impact of energy prices on energy consumption of agricultural sector. The intuition behind this equation is to capture the impact of energy prices indirectly through energy consumption on the agricultural sector productivity. The results report a negative impact of energy prices on energy consumption in agricultural sector. This means a decrease in energy consumption of agricultural sector due to a rise in energy prices. As energy consumption in agricultural sector has positive impact on agricultural sector productivity, therefore decrease in energy consumption will reduce agricultural sector productivity. Further, results also reveal that agricultural sector productivity has positively influence on the energy consumption in agricultural sector. The results also show that the lag of energy consumption significantly affect the agricultural sector, which implies that past shock to energy also affect the current agricultural production. We also find that industrial sector productivity has positive impact on energy consumption in industrial sector which shows that energy consumption in industrial sector increases with the increase in industrial sector productivity. Further, like energy consumption in agricultural sector, energy consumption in industrial sector also negatively related to energy price. A larger magnitude of energy price coefficient in the equation of energy consumption in industrial sector compared to energy consumption in

the agricultural sectors showing that rise in energy prices greatly affect the industrial sector productivity. Results also show a positive impact of industrial sector productivity on energy consumption in agriculture sector.

In short, our results, as a whole, show that both the agricultural and industrial sectors affect each other indicating the importance of both the sectors for the performance of each other. Further, results also reveal that impact of the agricultural sector on the industrial sector is higher than the impact of the industrial sector on the agricultural sector which implies that in Pakistan, the industrial sector is highly exposed to the growth in agricultural sector. Further, both the agricultural and industrial sectors productivity are adversely affected due to shock in the energy prices as shown through indirect channel of energy consumption in these sectors.

5. Conclusion and Policy Recommendation

The aim of the study was to examine the interdependence of agricultural and industrial sector productivities and to find out the impact of energy prices on these productivities. Results based on simultaneous equation method revealed a positive relationship between the agricultural and industrial sector productivities indicating interdependence of both the sectors on each other. Findings also concluded that the energy consumption has positive impact on the agricultural and industrial sector productivities. Further we also found that energy prices have negative impacts on agricultural and industrial sectors productivities indirectly through their influences on energy consumptions in agricultural and industrial sectors. Keeping in view our findings this study suggests the need to ensure smooth and consistent supply of energy with stable prices. It will help increase in productivity of both agriculture and industrial sector and thereby will enhance the overall economic growth of the country.

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