Determinants of Agricultural Output in Pakistan: A Johansen Co-integration Approach

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ABSTRACT

It is an understood fact that the improved inputs and modern machinery are important determinants of agricultural output, yet it is important to quantify the relationship. The study is aimed to analyze and identify the key the determinants of agricultural output. Variables used in the study are agricultural output, fertilizer consumption, improved seeds, labor employed in the sector, number of tractors, number of tube-wells and water availability. Data for these variables is time series for 1972 to 2012 which have been obtained from Agriculture Statistics of Pakistan Yearly Book and Pakistan Economic Survey Various Issues. Johansen co-integration approach has been used to compute the results. Results show that number of tractors in the sector is an important determinant of agricultural output. Study also concludes that improved seeds, water availability, number of tube-wells and labor employed in the agriculture sector are positively related to agricultural output.

Keywords: *Modern machinery, determinants, agricultural output, fertilizer, seeds*

INTRODUCTION

The word agriculture has been derived from the Latin word agricultura which is the combination of ager, "a field" and cultura, "cultivation". People have depended upon agriculture for years as the most important means of obtaining food. "The first people that started to depend on farming for food were in Israel and Jordan in about 80000 B.C." Agriculture became famous and indispensible because people no longer had to depend on just searching for food to keep them alive.[1]

Intense cultural rather than technological changes are necessary at first to allow adaption to the new mode of life. Once the shift has occurred, both cultural and technological changes become possible. To agriculturalists, survival is dependent upon getting the seeds to develop and grow in the soil that involves a good hard work.

Since 1948, agricultural production has doubled around the world, while total input use, including labor and land, has declined slightly. It implies that overall, agricultural productivity has increased. Hence, fast improvements of machinery have enabled fewer farmers to work with less land and obtain a greater output. Now a days, farmers produce higher valued products as a result of technological improvements in agricultural production.

Today modern tractors are being used by the farmers which are easier to use and can help farmers to achieve greater output. Tractors have better visibility as well as improved lighting systems for night time work and stylish fingertip controls that allow farmers to adjust quickly to changing field conditions. Use of improved and modern technology is also visible in the

[1] Solow, R. (1956), A contribution to the theory of economic growth. Quarterly Journal of Economics, Volume 70, pp. 65-94.

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other sub-sectors of agriculture. For example, computers are being used by the live stock producers to get a better information about their operations. Now, using modern computers producers can keep all their past records save which may help them to predict their future output gains or lose. Computers also help producers to observe and react to weather variability on a day-to-day basis. The internet is also playing a vital role in the development of the sector. It is increasing communication and business opportunities within the agricultural community.

Pakistan has an affluent and vast natural resource base, covering various environmental and climatic zones. Hence, the country has great potential for producing all types of agricultural commodities. Agriculture sector has always played an important role in generating the economic growth of Pakistan. The importance of agriculture to the economy of any nation can be seen in three ways: first, it provides food to consumers and inhabitants of the country; second, it is a source of foreign exchange earnings; and third, it provides a market for industrial goods. More specifically; the agricultural sector plays an important part in Pakistan's economy for the following reasons:

i. It contributes 21 percent to the GDP of the country.[2]
ii. Provides food to approximately 130 million people of the country. Shares about 60 percent of the country's total export earnings.
iii. Generates employment to almost 45 percent of the total work force in the country. [3]
iv. Being the main source of livelihood for the rural population of Pakistan.
v. Provides raw materials for many industries and a market for many locally produced industrial products.

The importance of agriculture of Pakistan can also be assessed by the fact that it is providing food to the rapid growing population of the country. According the 1998 census of Pakistan, the total population of Pakistan was 130 million with the population growth rate of 2.6 percent. This growth rate implies that each year 3.4 million people are added to the sector. Population of Pakistan has increased fourfold since its creation in 1947. While during this period the production of wheat, one of the major food crops of Pakistan, has increased only 2.9 times. Great efforts have been carried out to narrow the gap between population growth and food production. Yet these efforts have been subject to lot of criticism. If we glance at the foreign trade of the country, agriculture sector again dominates. Major exports of the sector are raw products such as cotton , rice and semi-processed and processed products such as cotton yarn, cloth, carpets and leather production .Agriculture is vital for sustainable improvements in internal and external balances.

Agriculture has been the dominant sector of the Pakistan since its independence. It is still contributing about 21 percent to GDP and employing 45 percent of the total employment.[4] It also provides raw material to industry and contributes to the country's exports. Agriculture sector is also a large market for the industrial products such as fertilizer, pesticide, tractors and agricultural equipment. Major crops of the agriculture are wheat, cotton, sugarcane, and rice. Agriculture sector of Pakistan may be divided into five subsectors comprising major crops, minor crops, fisheries, forestry and livestock. Livestock is the most important subsector of the agriculture. According to the Pakistan Economic Survey 2009-10, livestock contributes 10.8 percent in the GDP of Pakistan. Crops and livestock constitute the large part

[2] Pakistan Economic Survey 2012-13
[3] Pakistan Economic Survey 2012-13
[4] Pakistan Economic Survey 2012-13

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of the agricultural output. There are five different classes in the agriculture sector of Pakistan namely landlords, farmers, family farmers, share croppers and wage workers. [5]

Growth of agriculture is one of the necessary conditions for the overall development of the economy especially in the country like Pakistan where more than sixty percent of the population lives in the rural areas. Increasing production from the agriculture sector is regarded as the key factor for the growth of the economy. As agriculture grows, it extends resources to other sectors of the economy. This has been the base of successful industrialization. Thus, agricultural development has become an important requirement of structural transformation towards industrial development.

Agricultural performance of Pakistan remained slow from 1947 to 1953. In the six year Colombo plan (1951-57) industries were given more importance. The plan was suspended two years before its completion. The performance of agriculture declined in this phase of time due to an increase in water logging. Pakistan imported 1 million ton of wheat in 1952 to meet shortage. Government soon realized that agriculture sector should not be neglected and should be given equal importance along with the industry. The first five year plan (1955-60) was prepared by planning board and was released in 1957. It was the beginning of scientific planning in Pakistan. However, in practice this plan was not implemented mainly because of political instability. Agricultural sector remained neglected till 1960 due to several reasons. [6]

In the second five year plan (1960-65), government focused on the agriculture sector with a serious intention. The main objective of the government was to attain self-reliance in the basic production, raise the standards of food items, and increase the production of cotton and jute. To realize these objectives government took some strong measures like agrarian reforms, provision of machinery, and credit facilities to the farmers. Well-designed polices helped government to achieve its targets. Production of food grains increased by 27 percent which was above the target of 21 percent. Government also achieved the targets set for the production of cotton and sugarcane. The target set for the production of jute was 22 percent while the production increased by just 3 percent. [7]

In the third five year plan (1965-70), agricultural production increased to the great extent. Increase in the water availability, improved seeds, fertilizer and machinery increased the agricultural output from 6.2 percent in 1961-62 to 12 percent in 1967-68. Since 1970 to 2009, agriculture sector has not grown consistently. There are much fluctuations in the growth rate of the agriculture in this period especially in the decade of 1990. Use of machinery, fertilizers, improved seeds and water have increased during the last two decades and studies show that with the increase in the volume of these inputs the productivity of the sector has grown significantly. [8]

Introduction of technology in agriculture is an important factor for the productivity growth. Hence technological change plays a vital role in the growth of the sector and the overall development of the economy. “Technological change involves a shift in the production function which relates the quantity of output to the quantity of inputs enabling greater output

[5] Zaidi, A., (2005). “ISSUES in PAKISTAN ECONOMY”, 2nd Revised, Expand Edition, Oxford University Press, Usa.

[6] http://www.scribd.com/doc/19702378/History-and-Performance-of-Agriculture-in-Pakistan.

[7] Ibid.

[8] Zaidi, A., (2005). “ISSUES in PAKISTAN ECONOMY”, 2nd Revised, Expand Edition, Oxford University Press, USA.

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quantity or quality or both to be produced with the same volume of land, labor and capital." [9] Often these changes result from the variation in quality of inputs such as enhanced forms of machinery or more highly knowledgeable labor. Technological change is aimed at saving the relatively limited or more costly resources.

Agricultural productivity plays a central role in the growth of the sector and eventually in the development of the economy. According to the Krueger and Schiff (1999), the countries with high productivity growth were the successful industrializes. The necessary factors that might contribute to a high agricultural growth consist of the growth of cultivated area, improved use of water and other important agricultural inputs such as fertilizers, seeds and labor. An increase in cropping strength, technological change, and technical efficiency are also regarded as key factors of the agricultural growth. "Technological change is the outcome of research and magnification efforts, whereas technical efficiency with which fresh technology is implemented and used more successfully is affected by the course of information, enhanced infrastructure, accessibility of funds, quality inputs, and farmers' decision-making capabilities." [10]

Adoption of technology requires adequate incentives for producers. Investment will not be made in agriculture unless it is fruitful. "One of the most important determinants of adoption of new technology is adequacy of markets for agricultural output and inputs." [11] If there are not proper markets for the output grown by the farmers, famers will be reluctant to make any investment in the form of new technology knowing that they will not be able to earn enough money to recover these extra costs made on new technology. Hence the availability of adequate markets for the agricultural output is the precondition for the adoption of technology in agriculture.

Agriculture can also play an essential role in the economic growth through the stipulation of food to the people, growth of exports, transmition of manpower to other sectors, contribution to capital formation, and securing markets for industrialization. Increase in the agricultural productivity is important for the realization of these roles. As productivity increases, the real cost of a product decreases. As the cost of a product decreases, the purchasing power of consumers increases since they are now able to buy more goods and services with their incomes. The increased purchasing power of consumers increases the overall demand for goods and services which eventually promotes the overall economic growth. Increase in the agricultural productivity is mainly due to the introduction of new technologies in the sector.

Toynbee [1884] showed that the technological change in agriculture lowers the food prices and makes the industrial labor cheaper. Technological change influences production and consumption of agricultural and nonagricultural products. Consequently, technological change in agriculture affects the relative prices of agricultural and nonagricultural products. These changes in product markets result in additional changes in factor markets. Thus changes in agricultural productivity can have an effect on foreign exchange earnings, prices of the food, labor used in agricultural and nonagricultural production and relative factor prices.

Impacts of technological change in agriculture are manifold. It can be thought that technological change is an important factor for increasing agricultural output. Yet

[9] Richard E, et al., (1979),"technological change in agriculture", American Association for the Advancement of Science.

[10] Iqbal M, Et Al, 2002. Science & Technology Based Agriculture Vision Of Pakistan And Prospects Of Growth.

[11] Wharton R, "Subsistence Agriculture And Economic Development", Aldine Publishing Company, 1976.

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technological change is not the only determinant of the increased agricultural output. It is still a question that to what extent technological change affects the agricultural production. Greater agricultural output can also be obtained by increasing the quantity and quality of other agricultural inputs such as labor, fertilizer, improved seeds, pesticides and water availability etc.

Basic purpose of the underlying study is to determine the contribution of machinery and other inputs such as labor employed in the agriculture, fertilizer consumption, improved seeds, number of tube wells and water availability to the agricultural output. Due to the unavailability of data study uses the number of tractors used in agriculture to represent the agricultural machinery.

OBJECTIVES OF THE STUDY

The objectives of the study are to:

1. Determine the extent to which the improved inputs such as fertilizers, improved seeds, and labor increase the agricultural output.
2. Examine the impact of water availability on the agricultural production.
3. Analyze the effect of increased number of tractors in the sector on agricultural output.
4. Suggest further for policy recommendations.

GROWTH OF THE AGRICULTURE SECTOR OF PAKISTAN

The main target of any country in the world is to achieve economic development. There are many factors which are responsible for economic growth. These vary from country to country. One of the important factors of economic growth is agriculture sector. Agriculture sector strives to achieve self-sufficiency in food, fiber, sugar, rice, wheat and other crops. It provides raw material to local industry and also generates export surplus to earn foreign reserves.

Growth of the agriculture sector was the forerunner to the modern revolutions in industry that stretched along the world, from England in the mid 18th century to Japan in the late 19th century. [12] More lately, fast agricultural growth in China, Vietnam and India was the predecessor to the climb of industry. In the agriculture-based countries, agriculture sector is necessary to growth, which in turn is essential to lessen the poverty and food insecurity.

Agriculture growth can encourage overall economic growth. This is evident from Sub-Saharan Africa where the rate of growth of agriculture sector was almost zero for the period of early 1970s and remained negative during the years of 1980s and early 1990s. But in the past few years positive growth rates have been observed in Sub-Saharan Africa which implies that the agriculture could be the key factor of fast growth and can also play vital role in poverty reduction. Agriculture stimulates overall growth because in the countries with low income the contribution of agriculture in the GDP is relatively large and hence a strong growth in agriculture is required to boost the overall growth. [13]

The performance of agriculture sector in Asia over the last few decades has been significant. “Between 1961 to 2001, the production of cereal has been increased from 309 million tones

[12] WDR 2012
[13] Ibid

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to 962 million tones." [14] This increase in the production is for the most part owing to the increase in the productivity in the agriculture sector. Thus productivity is imperative feature and very important factor in the process of economic growth. In Asia, the economic growth is more rapid as compared to Africa. The importance of agriculture sector in Asia can be assessed from the fact that agricultures sector absorbs almost sixty percent of the total working population in this particular region.

The economy of Pakistan has not been consistent since 1947. Yet the contribution of agriculture sector in the country's GDP has been significant throughout these years. Agricultural output has grown annually at about 3.5 percent. During 1960's and 1980's the performance of agriculture sector was quite impressive. The decade of 1950 and 1970 was not good for the agriculture sector. The decade of 1990 was bad for overall economic growth of Pakistan. In 1992 and 1996 the performance of agriculture sector was at the low levels with the annual growth rate of -5.29 and .12 percent respectively for these two years. The reason for the poor performance of the agriculture sector in these two years may be the political instability along with other factors. The agriculture sector of Pakistan has grown consistently in the current decade of 2000 with the average annual growth rate of about 3.5 percent.

The growth in agriculture has come largely from major crops like wheat, cotton, rice and sugarcane. The contribution of minor crops has not been as much as the major crops. There may be several reasons for this. But the most important reason is the lack of government policies toward minor crops. The agricultural production has been increasing significantly since 1947. The average value of agricultural output for the last seven years is about 1050 billion rupees. The important factors for the increased agricultural production are increased inputs including irrigation water, seeds, machinery, fertilizer, credit and labor. [15]

The sector's share in the GDP has been declining since the independence. The share of agricultural sector in the country's GDP was about fifty percent in the decade of 1950 while in 2009 the share has declined to twenty one percent. The contribution of industry in the GDP was about ten percent in the decade of 1950 while in 2009 the share has increased to twenty five percent. At the time of independence Pakistan was an agriculture based county but with the passage of time the country moved toward structural change with the industry as its key sector. The share of agriculture sector in GDP has not declined only in Pakistan but the trend is also obvious in East and South Asia where the share of agriculture in the GDP is now less than twenty percent.

The role of agriculture sector in the economic development of Pakistan cannot be denied. Pakistan is still characterized as agriculture based country. Agriculture sector is a main source of employment in Pakistan as more than fifty percent of its population lives in the rural areas. In the rural areas, agriculture is the only source of employment. According to the economic survey of Pakistan agriculture is still a foremost source of employment with the 45 percent of total employment is provided by the agriculture sector. High employment results in increase in the GDP and high per-capita income. High per-capita income results in better living standard of people which ensures better health facilities and quality of education etc which are the indications of economic growth and development.

One of the primary responsibilities of any government is to lead its country on the course of economic development. Government can increase the expenditures on development project

[14] Lauren m. " growth and the investment climate: progress and challenges for asian economies" institute of development studies and overseas development institute, march 2006.

[15] Pakistan Economic Survey 2012-13

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by increasing its tax revenues. Agriculture sector can help government in increasing its tax revenues. As agriculture sector is the major source of employment and contributes twenty one percent in the country's GDP, it results in higher per capita income of people. As per capita income of individuals increase, government can collect more tax revenue from the individuals. Agriculture sector also provides raw material to industries. So as agriculture sector grows it results in the growth of industry as well. Expansion of industrial sector provides an incentive for the government to increase its tax revenues. In this way agriculture sector is an important factor of increasing the tax revenues of the government and hence the cause of economic development.

During the last twenty years some important changes have taken place in the agriculture sector. Especially, livestock has emerged as a key subsector. According to the economic survey 2012-13, livestock has a share of 10.8 percent in the GDP of Pakistan. Similarly, the contribution of fisheries and forestry in the GDP has grown significantly. Changes have also occurred within the crop sector. Cotton has gained an equally strong importance as wheat.

In these manifold ways agriculture sector can contribute in the economic development of Pakistan. In order to further enhance the development of the economy the government should introduce policies which increase the efficiency of agriculture. E.g. government should introduce modern means of production through the introduction of technology in the agriculture sector. The government should also amend land reforms as small lands are not as productive as the large ones and should also increase the ownership of land to farmers and must take steps to remove feudalism. Effective measures for agriculture will certainly contribute to the development of the weak economy of Pakistan.

LITERATURE REVIEW

Herr (1966) made a comparison of agriculture in US with agriculture in Australia with respect to technological change. Variables such as agricultural output, labor employed, capital employed, labor productivity, capital labor ratio and technological change were used in the study. Study used Solow model to arrive at results that conclude that over the past three decades the rate of technological change has been four times as fast in the US as in Australia.

Robinson (1971) anticipated technical efficiency, technological change and spillovers caused by human resource accumulation for thirty nine developing countries. The study employed cross-sectional regression analysis and found that, on the average, the share of productivity in total growth was 15 percent in these economies. However, the share was 50 percent for developed countries.

Fan (1991) examined the effects of technological change and institutional reform on production growth in Chinese Agriculture. Study employed the frontier production function approach to obtain the results. Results show that technological change accounts for 15.7 percent of total agricultural production growth in China. The estimates of the frontier production functions also indicate that traditional inputs are still important to China's agriculture. In contrast, the coefficients of modern inputs, e.g. chemical fertilizer and machinery inputs, are highly significant.

Hussain and Ishfaq (1997) analyzed the determinants of agricultural production in Pakistan. Variables included in the studied were farm crop output (Y), farm crop area (N), labor (L), irrigations (R), fertilizer (F), total tractor supply (T), and total credit distributed (C). Cob-douglas production function was used to estimate the results. Results show that farm crop area, fertilizers and total tractor supply play a significant role in the determination of agricultural output.

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Blanchard (1998) explored the relationship between technological change, productivity growth, and unemployment. Study used Mortensen-Pissarides model to show that technological change triggers jobs and worker flows, and through which affects unemployment. Results also showed that wage in a given job grows over time, but more slowly than productivity.

Mathijs and Vranken (2000) estimated technological change and technical efficiency for Bulgaria and Hungary. The study used Tobit Regression Model to obtain the results. Variables such as average age of farmers, education, and gender was used as a proxy for stock of resources. Results show a positive relationship between stock of resources and technical efficiency.

Bauer and Bender (2002) investigated the impact of executive and technological variations on gross job and flows of workers. The study used German employer-employee matched panel data set to estimate the results. Results indicated that organizational alteration is skill-biased because it lessens net employment growth rates of un-skilled and medium-skilled workers by means of higher job devastation and division rates, whereas the employment blueprints of skilled workers are not affected significantly. They also found that new information technologies do not have significant impact on gross job and flows of workers.

Hsu, Yu and Chang (2003) analyzed the productivity growth in China's agricultural sector over the period between 1984 and 1999. The study used Malmquist productivity indexes, Data Envelopment Analysis (DEA) approach and Tobit regression model to estimate total factor productivity growth for the agriculture sector of china. The output variables used in the study were total gross output value of farming, forestry, animal husbandry and fishery while input variables were number of rural labor, irrigated area, machinery, chemical fertilizer, and electricity consumption. Results indicate that the major source of growth comes from technical progress.

Askenazy and Galbis (2004) examined the impact of technological and organizational changes on labor flows. The variables used in the study were technology (computer and net), chain (associated systems) , flexibility (rotation and just time), quality, employees, and education. Regression analysis was used in the study to estimate the results. Results show that on the aggregate level, labor flows of all workers are accelerated by the combination of flexible job assignment practices and information and communication technologies (ICT).

Hamid and Ahmad (2006) analyzed the major factors which were responsible for agricultural growth and productivity. The variables included in study were value added in the agricultural output(y), labor employed in agriculture (L), capital stock in agriculture (K), intermediate inputs in agriculture (IP) and level of technology (A). Cobb-douglas production function was used to estimate the results. Results show a negative impact of technological change and efficiency on employment generation prospects in agriculture sector of Pakistan.

Swinnena and Vrankena (2006) measured technological change, technical efficiency and productivity for the period between 1997 and 2001. The study used a set of farm survey data from five European transitional economies Albania, Bulgaria, Czech Republic, Hungary and Slovakia. Results show a significant impact of reforms on TFP, technical efficiency and technological change in the agriculture sector of these economies.

Hye, Shahbaz and Din (2007) explored long-run relationship between output, technological advancement and agricultural terms of trade by using the Nerlovian Supply Response (NSR) model in case of Pakistan. Results show that technological advancement and agricultural terms of trade are important variables for determining agricultural output growth in long span of time.

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Kiani, Iqbal and Javed (2008) explored the relationship between total factor productivity and agriculture research expenditures for the period of 1970-2004. Tornqvist-Theil index (TTI) approach was applied for the measurement of total factor productivity (TFP) using outputs and inputs for 24 fields. Variables included in the study were Total Factor Productivity (TFP), research expenditures, number of tubewells, improved seeds distributed, and the number of tractors. Results show that agricultural research expenses, number of tractors, and tubewells have positive and significant impact on TFP.

Ahmad, Chaudhary, and Ilyas (2008) analyzed the trends in total factor productivity in Pakistan's agriculture sector. Variables included in the study were value added in agriculture(Y), capital input (K), labor input (L), area under cultivation (A) and time (t). The growth accounting method was used to estimate the results. Results show that the total factor productivity is the most important source of growth.

Ludena (2010) analyzed Agricultural Productivity Growth, Efficiency Change and Technical Progress in Latin America and the Caribbean between 1961 and 2007. The study used Malmquist index approach to obtain the results. Variables employed in the study were animal stock, land, fertilizer, tractors, and labor. The results indicate that among developing regions, Latin America and the Caribbean have the highest agricultural productivity growth. Study also concludes that the highest growth has occurred in the last two decades mainly due to the introduction of new technologies.

Parminder and Amarjeet (2012) attempted to investigate growth rates of TFP and technical efficiency in agriculture sector for the Indian economy using time series data between 1971 to 2004. The variables used in the study were value of output, value of machines, value of labor and value of fertilizer used in the sector. They used data envelopment analysis to compute the results. They found that growth in productivity is negative for Indian economy and output growth of the economy was mere due to growth in inputs in agriculture sector. They also concluded that the change in efficiency was insignificant.

DATA AND METHODOLOGY

Data Description and Variables

Data used in the study was collected from Agriculture Statistics Of Pakistan Yearly Book and Pakistan Economic Survey. Variables used in the study were agricultural output measured in billion rupees, number of tractors, fertilizer consumption measured in tons, water availability measured in million acre feet, improved seeds measured in tons, number of tube wells and labor employed in agriculture measured in millions.

Methodology and Model Specification

Given the nature of the data, following model is specified:

$$AO_t=\beta_0+\beta_1 FC_t+\beta_2 IS_t+\beta_3 LEA_t+\beta_4 NT_t+\beta_5 NTW_t+\beta_6 WA_t+\varepsilon_t$$

Where,

t=1972, 1973, ……., 2012

AOt= Agriculture Output at time t (billions rupees)

FCt= Fertilizer Consumption at time t (000 tonns)

ISt= Improved Seeds in Agriculture at time t (000 tonns)

LEAt= Labour Employed in Agriculture Sector at time t (million)

NTt= Number of Tractors at time t

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NTWt= Number of Tube wells at time t

WAt= Water Availability at time t (million acre feet)

The data for these variables was obtained from Agricultural Statistics of Pakistan Yearly Book and Pakistan Economic Survey. The dependent variable is agricultural output. Johansen Cointegration technique is applied on the data to obtain the results.

The fact that non-stationary processes can have linear combinations that are stationary was called cointegration by Granger. Granger used it in order to check long run relation between econometric variables. Concept of cointegration is used to describe the long run relation between the variables. Cointegration technique in order to check out the relationship between time series variables has been very famous since its introduction in 1990s.

Johansen cointegration test, named after Soren Johansen, is a method for testing cointegration of a number of time series variables. The most desirable case is when all the variables integrated of the same order. However, it is essential to stress here that this is not the always case, and that even in cases where a mix of I(0), I(1), and I(2) variables are present in the model, cointegrating relationships might well exist. [16]

Process of Johanson cointegration technique is carried out by the vector autocorrelation model of order p given by:

$$\mathbf{Y_t = \mu + A_1\ y_{t-1} + \ldots + A_p\ y_{t-1} + \varepsilon_t} \qquad \mathbf{(1)}$$

In above equation $\mathbf{Y_t}$ represents n-by-1 vector of variables which are supposed to be the integrated at order 1.

The above model can also be represented in following form:

$$\Delta \mathbf{y}_t = \boldsymbol{\mu} + \boldsymbol{\Pi} \mathbf{y}_{t-1} + \sum_{i=1}^{p-1} \boldsymbol{\Gamma}_i \Delta \mathbf{y}_{t-i} + \boldsymbol{\varepsilon}_t \qquad (2)$$

where

$$\boldsymbol{\Pi} = \sum_{i=1}^{p} \mathbf{A}_i - \mathbf{I} \text{ and } \boldsymbol{\Gamma}_i = -\sum_{j=i+1}^{p} \mathbf{A}_j \,. \qquad (3)$$

If we reduce the matrix Π to the rank equal to r smaller than n, there will be n-by-r matrices specifically α and β having same rank of r in such a way that Π equals αβ′ and β′y which would be stationary. In above relation, r shows the number of cointegrating relationships. Whereas, α and β are said to be the adjustment parameters in VEC model. It is important to note that for any given r, MLE of β shows the combination of y_{t-1} capitulates r with largest canonical correlations of Δy_t with y_{t-1} when checked and corrected for lagged differences and deterministic variables if present. There are two likelihood ratio tests of significance which are followed in the procedure of Johansen cointegration technique. These two tests are names as trace test and maximum eighen value test.

$$J_{trace} = -T \sum_{i=r+1}^{n} \ln\left(1 - \hat{\lambda}_i\right) \qquad (4)$$

$$J_{max} = -T \ln\left(1 - \hat{\lambda}_{r+1}\right) \qquad (5)$$

[16] Asteriou, D., (2006). " Applied Econometrics". P-344, Palgrave Macmilllan

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Whereas, T represents the size of sample and λi denotes the ith largest canonical correlation.

In case of trace test, we shall test the null hypothesis that there are r cointegrating vectors versus the alternative hypothesis that there are n cointegrating vectors. Whereas in case of max eighen value test, we test the null hypothesis that there are r cointegrating vectors versus the alternative hypothesis that there are r+1 cointegrating vectors. Critical values for both of the tests can be observed in Johansen and Juselius tables.

Although Johansen's methodology is typically used in a setting where all variables in the system are I(1). Yet, Johansen explains that before applying the test we need to test order of integration of the variables in the given system.

RESULTS AND INTERPRETATION

In order to find the impact of fertilizer consumption, number of tractors, water availability, use of improved seeds, number of tubewells and labour employed in agriculture on agricultural output study uses the following equation:

$$AO_t=\beta_0+\beta_1 FC_t+\beta_2 IS_t+\beta_3 LEA_t+\beta_4 NT_t+\beta_5 NTW_t+\beta_6 WA_t+e_t$$

Where

t=1972, 1973, ……., 2012

AOt= Agriculture Output at time t

FCt= Fertilizer Consumption at time t

ISt= Improved Seeds in Agriculture at time t

LEAt= Labour Employed in Agriculture Sector at time t

NTt= Number of Tractors at time t

NTWt= Number of Tube wells at time t

WAt= Water Availability at time t

First study checks the level of integration of variables in the model. For this purpose study uses Augmented Dickey Fullar (ADF) test. All the variables are found to be integrated at order 1. The results of test are as follows:

Table 1. Unit Root Test (ADF) at 1st difference

Variables	*Constant*	*Constant & Trend*
AO_t	2.54743 (1)	1.0007 (1)
FC_t	0.2106 (1)	-1.6972 (1)
IS_t	0.55559 (1)	-1.44361 (1)
LEA_t	0.68895(1)	-1.86324(1)
NT_t	1.18397(1)	-1.12387(1)
NTW_t	1.19425 (1)	-2.46089 (1)
WA_t	-2.18140 (1)	-2.60794 (1)

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Note: The ADF unit root test is based on lag length given in brackets. Values reported in the table are t-values.

Table 1 shows that all the variables used in the study are integrated of the same order. After testing for unit root, study uses Johensen Cointegration test to check the long run relationship between variables in the study. Before appling the Johenson Cointegration test, study finds the optimal lag length.

Table 2. VAR Lag Order Selection Criteria Endogenous variables: AO FC IS LEA NT NTW WA Exogenous variables: CSample: 1972 2008 Included observations: 34

Lag	LogL	LR	FPE	AIC
0	-1527.103	NA	3.66e+30	90.24136
1	-1322.378	313.1083	4.10e+26	81.08108
2	-1260.775	68.85063*	2.89e+26*	80.33972*

* indicates lag order selected by the criterion

LR: Sequential modified LR test statistic (each test at 5% level)

FPE: Final prediction error

AIC: Akaike information criterion

Tables 2 shows that AIC criteria proposes the optimal lag length equal to two, so study includes two lags in finding the cointegration amongst variables.

Table 3. Johenson Cointegration Test (Trace Statistics)

Hypothesized No. of CE(s)	*Trace statistic*	*Critical Value(.05)*	*Prob.***
None *	335.2917	125.6154	0.0000
At most 1 *	213.2580	95.75366	0.0000
At most 2 *	128.6100	69.81889	0.0000
At most 3 *	63.06475	47.85613	0.0010
At most 4	24.31163	29.79707	0.1876
At most 5	9.777275	15.49471	0.2983
At most 6	1.100220	3.841466	0.2942

Trace test indicates 4 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Table 3 shows the four co-integrating vectors with trace statistics which is a strong evidence for long run relationship amongst variables of model.

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Table 4 Johenson Cointegration Test (Maximum Eigen Values)

Hypothesized No. of CE(s)	*Max-Eigen Statistic*	*Critical value (.05)*	*Prob.***
None *	122.0337	46.23142	0.0000
At most 1 *	84.64797	40.07757	0.0000
At most 2 *	65.54529	33.87687	0.0000
At most 3 *	38.75311	27.58434	0.0012
At most 4	14.53436	21.13162	0.3229
At most 5	8.677055	14.26460	0.3140
At most 6	1.100220	3.841466	0.2942

Max-eigenvalue test indicates 4 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values.

Table 4 shows again the four cointegrating vectors in the model, which is again a strong evidence for long run relationship amongst variables of our model. Now, study discus the long run coefficients of model.

Table 5. Long Run Coefficients

Variables	*Coefficients*	*T-Value*
Constant	28.135	3.563
FC_t	-0.026	-0.752
IS_t	1.634	10.253
LEA_t	56.713	6.265
NT_t	0.001	31.432
NTW_t	0.002	32.54
WA_t	8.707	8.906

Table 5 shows the long run relationship among the variables. It shows that fertilizer consumption has negative but insignificant impact on agriculture output. Improved seeds have positive and highly significant impact on agriculture output. One thousand ton increase in the improved seeds leads to increase the agricultural output by 1.634 billion rupees. Labour employed in agriculture sector also has positive and highly significant impact on agriculture output. Quantitatively, one million increase in the labor employed in agriculture sector leads to increase the agricultural output by 56.173 billion rupees. Number of tube wells has also a significant impact on agricultural output. Addition of one tube well increases the agricultural output by .002 billion rupees. Water availability also has positive and significant impact on agriculture output. Finally, numbers of tractors have highly significant impact on agriculture

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output. Addition of one tractor to the sector increases the agricultural output by .001 billion rupees.

Table 6 Vector Error Correction Model

VARIABLES	*COEFFICIENT*	*S.E*	*T-VAUES*
ECT(-1)	-0.57462	0.16643	-3.45268
D(AO(-1))	-0.064432	0.42146	-0.15288
D(AO(-2))	0.349517	0.31449	1.11137
D(FC(-1))	-0.016728	0.06324	-0.26451
D(FC(-2))	0.038860	0.06372	0.60982
D(IS(-1))	0.081471	0.43069	0.18916
D(IS(-2))	0.042807	0.42530	0.10065
D(LEA(-1))	42.55194	13.4343	3.16741
D(LEA(-2))	20.50107	15.3606	1.33465
D(NT(-1))	-0.001981	0.00209	-0.94781
D(NT(-2))	-0.002241	0.00234	-0.95950
D(WA(-1))	5.16E-05	0.00029	0.18068
D(WA(-2))	0.000196	0.00024	0.83107
D(NTW(-1))	-1.647550	2.54182	-0.64818
D(NTW(-2))	0.010061	2.23406	0.00450
C	13.21070	19.6968	0.67070

Table 6 shows the coefficients of vector error correction model based on maximum two lag length and Error Correction Term. Result shows that ECM value is correctly negative and significant, so there is also short run relationship found in model of the study. The speed of adjustment from short run disequilibrium to long run equilibrium is 24% in a year.

Table 7. Model Summary

R-squared	0.694361	Akaike AIC	10.28773
Adj. R-squared	0.424679	Schwarz SC	11.01331
Sum sq. resids	21518.33	Mean dependent	39.53658
S.E. equation	35.57786	S.D. dependent	46.90560
F-statistic	2.574740	P-Value(F-Statistic)	0.000000
Log likelihood	-153.7475		

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Table 7 shows overall summary of the fitted model. P-Value of .0000 shows that the overall model is significant. Value of R-square is .6943 which shows that almost 70 percent of the variation in the endogenous variable is explained by exogenous variables which also show that the overall model is a good fit.

Study also does the diagnostic test to find the possible problem in the data.

Table 8. Diagnostic Tests

Checks	*LM version*	*Probability*
Serial Correlation (χ^2)	0.695	0.405
Normality (χ^2)	2.668	0.263
Heteroscedasticity (χ^2)	0.002	0.967

Table 8 shows that all p-values of relevant test are greater than 0.2, so there is a strong evidence that there is no problem of serial correlation and hetroscedasticity in the model. Error term of model is normally distributed and functional form of our model is correct.

CONCLUSION AND POLICY RECOMMENDATION

Study concludes that mechanization play an important role in the growth of agriculture sector of Pakistan. Empirical findings show that usage of modern tractors, improved seeds, water availability, number of tube wells and labor employed in agriculture sector are important determinants of agricultural output. Study also shows that fertilizer consumption is contributing insignificantly to agricultural output. The reason for insignificant impact of fertilizer consumption on agricultural output is the illiteracy of poor farmers in the country. Farmers living in distant rural areas do not know the optimal usage and proper timing of fertilizers.

On the basis of current study, the following policy recommendations are made:

a) Number of tractors should be increased in the sector. Government should launch tractor subsidy schemes so that the number of tractors may be increased in the sector.

b) Government should subsidize important agricultural inputs such as fertilizer, seeds, and pesticides so that poor farmers may access these inputs easily.

c) Government should improve canal system in order to increase water availability.

d) Government should advise ZTBL and all commercial banks to issue long-term loans to farmers on low interest rates since many poor farmers are not able to manage to pay for mechanization necessary for cropping.

e) Advertisement should be enhanced in order to bring awareness among people about the importance of improved machinery in agriculture sector.

f) Government should play an important role in educating the farmers. If the farmers are trained and educated, they can make use of the available technology. They should also be guided the appropriate quantity of fertilizers so that fertilizers can improve yielding more output to them.

g) Government should establish more agricultural universities in order to enhance research and development in the sector.

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h) Government should introduce the land reforms in order to eliminate feudalism so that the wide disparity of income between landlords and poor farmers may be cut down and area under cultivation may be increased.

i) Through print and electronic media, government should brought awareness to the rural farmers about the proper usage of fertilizer, pesticides and other inputs.

j) Government should organize seminars on the importance of agricultural development.

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