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MACRO DETERMINANTS OF PRODUCTIVITY GROWTH OF GRAIN CROPS (RICE AND WHEAT) IN PAKISTAN: A TIME SERIES ANALYSIS

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ABSTRACT-*The present study was conducted to estimate macro determinants of Productivity growth of major grain crops (wheat and rice) in Pakistan. First Total Factor Productivity (TFP) growth was estimated by using Tornqvist-Theil index for the time period of 1971-2010 and then Johansen's Cointegration approach was employed to find the relationship between macro variables and Total Factor Productivity growth of these grain crops. Augmented Dickey Fuller test (ADF) was applied to check the stationarity of data. All variables were stationary at first difference except two variables (inflation rate and sum of major grain crops export and import as percent of agricultural GDP). These two variables were stationary at level form. The coefficients of primary school enrolment, road length and agricultural expenditure were found significant and positive in the long-run. The inflation had significant negative effect on TFP of major grain crops. The variable of sum of grains exports and imports as percent of agricultural GDP was positively associated with productivity growth of wheat and rice crops. Over all, the results showed that policies which promote early education, improve infrastructural development, facilitate grain crops trade and ensure price stabilization; would lead to improve productivity growth of grain crops in Pakistan.*

Keywords: Tornqvist-Thiel index, Total Factor Productivity, major grain crops, Augmented Dickey Fuller, Cointegration

1.INTRODUCTION

Productivity growth plays a vital role in accelerating the pace of economic growth. This growth rate in agriculture has been persistent by the technological progress embodied in the high yielding varieties specifically of the major grains crops and with favorable investment in irrigation, research and development and rural infrastructure [3]. Agricultural growth, in turn, has played considerable role in the overall economic growth with a growth rate of 2.53 percent [14].

Pakistan is a low income developing country having a population growth rate of 1.92 percent in 2015. With the current population growth rate, it is expected to be doubled by the year 2060 and will be the 4th largest populous state of the world. Total cultivated area has increased by 40 percent during the past 60 years, while there has been more than 4 times increase in population that put pressure on cultivated land. Wheat production, a major food crop, increased considerably during the past 60 years but yet the country is marginal importer of wheat. Tremendous efforts are needed both in technology advancement and population control to narrow the supply-demand gap in food [14]

Reducing poverty, hunger and food insecurity are pre-requisites for economic development. Food security and economic growth mutually interact and reinforce each other in the development process [27]. The extra-ordinary rise in food prices in the latter part of the first decade of 21st century raised an alarm bell on food security, particularly for the developing world. To achieve food-secure, pro-poor and sustainable agricultural growth, Pakistan needs to adopt a comprehensive approach towards increasing productivity of all foods particularly of wheat and rice.

Major grain crop production on a sustainable basis is the foundation of food availability and the adequate food supply at affordable prices is the cornerstone of food security policy of all nations of the world including Pakistan. Pakistan has made significant progress in increasing supplies of food grains. Per capita availability of cereal crops increased from 120 kilograms in 1961 to 154 kilograms in 2010-11 of which, more than 80 percent is accounted for by wheat and rice. However, daily average calories availability is substantially lower than the average of other developing and developed countries by 10 percent and 26 percent, respectively [1].

According to recent estimates by UN interagency Assessment Mission (2010), the current requirement of grain crops in Pakistan is higher than its production. If population grows at an assumed rate of 1.82 percent per year, the country will remain a net importer of grains. A huge rise in the size of population is indeed termed as an important constraining factor for achieving the overall national development goals and sustained economic growth. With this continual population growth, diminishing supply of per capita available land, limits to further expansion of cultivated land, slowing returns to further input intensification and relatively high income elasticity of food in developing countries like Pakistan, there is growing need for food supply increases that could only originate by increasing efficiency and productivity growth rather than increase in inputs [4]. Major grain crops are losing comparative advantage in the international market. Therefore, emphasis on increasing grain crops productivity on a sustainable basis is imperative to ensure the food security in the country [1].

According to the neo-classical growth accounting framework, output growth is the sum of growth in capital accumulation, growth in labour and growth in productivity or efficiency. Therefore, for a given mixture of factor inputs (capital and labour), the shifts in the production functions are engendered by the improvements in productivity growth or efficiency. Government policies also have effect on productivity growth of major grain crops. A small number of studies have attempted to study the effect of macroeconomic policies on

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productivity growth of major grain crops in recent years. However, the sound effect of most of these determinants still remains an open issue with no clear ending. More significantly, the majority of the studies on the determinants of productivity growth has been paying attention on developed countries. The present study, therefore, seeks to examine the effect of different macroeconomic factors on productivity growth of major grain crops in Pakistan and suggest suitable policy measures to enhance the productivity growth of major grain crops.

2.MATERIAL AND METHODS

The present study has been conducted to estimate the productivity growth of major grain crops and to identify the causes of low productivity growth of grain crops in Pakistan. Time series data on the production of wheat and rice, inputs being used in the production process and data of different macro variables (considered to effect productivity growth) have been collected from different published documents to investigate their impact on total factor productivity growth of Pakistan's major grain crops for the time period of 1971-2010.

Description of Data on Macro Variables

The description of factors contributing to TFP growth of grain crops is given below.

Human Capital Development

Human capital is often regarded as the accumulation of education. The studies have put forward that educational change influence markedly productivity and economic growth. [2] and [24] used secondary school enrollment to capture the effect of education on total factor productivity. The present study used the time series data on primary schools enrollment as a proxy for human capital development of the labor force in agriculture.

Infrastructural Development

Infrastructure is frequently pointed out in the literature to be a crucial factor effecting productivity of agriculture. Expansion in infrastructure reduces the direct and indirect cost of production. [17] stressed the importance of infrastructure in enhancing productivity in developing economies.

Credit Resources

Easy access to credit enhances productivity of firm and contributes to total factor productivity of the overall economy. Credit finds new areas of investment under the efficient resource allocation. [2] used credit as percent of GDP as an indicator of financial development.

Openness of Agricultural Economy

Openness is generally believed to have a favorable impact on economic growth through increasing productivity of the economy. It is believed that more open economies can grow more rapidly through greater access to cheap imported intermediate goods, larger markets, and advanced technologies that contribute to total factor productivity growth.

Macroeconomic Stability

The impact of inflation on growth and productivity is somewhat controversial among theorists and policy makers. [21] investigated the negative effect of inflation on TFP in the low- and middle-income countries.

Expenditure on Agricultural

With the increase in expenditure for agriculture sector under five and ten years plans, expenditure on major grain crops (wheat and rice) ultimately increased due to their utmost importance. The data on agricultural expenditure was in million rupees in different five years and ten year plans which were collected and modified as agriculture expenditure on grain crops as a percentage of agricultural GDP.

Improved Seed Distribution

Improved seed is a key input and can determine the productivity of a crop to a large extent and data of seed distribution were collected from various issues of Agricultural Statistics of Pakistan.

TFP growth rate of Grain Crops

Total factor productivity (TFP) growth of grain crops (wheat and rice) estimated in the first stage analysis has been used as dependent variable to estimate the macro determinants of major grain crops. TFP growth is also presented in appendix 1.

Estimation Procedure

Measurement of Total Factor Productivity (TFP) of Major Grain Crops

The main purpose of this sub section is to describe a computational method used in deriving an index of total factor productivity of wheat and rice crops, over the time of study period. A total factor productivity index may be applied to binary comparisons, where two time periods or two cross-sectional units compared. It may also be employed to a situation where the TFP index is computed for several cross-sectional units [3]. The most frequently used formulation by [6;5;26] is applied. Expressed in logarithmic form, the Tornqvist-Theil total factor productivity index is given as follow:

$$\ln\left(TFP_t/TFP_{t-1}\right)=\tfrac{1}{2}\sum_i\left(R_{it}+R_{it-1}\right)\ln\left(Y_{it}/Y_{it-1}\right)-\tfrac{1}{2}\sum_i\left(S_{jt}+S_{jt-1}\right)\ln\left(X_{jt}/X_{jt-1}\right) \quad (1)$$

Where R_{it} will be the share of i-th output in total revenue; Y_{it} will be output *I*; S_{jt} will be the share of input *j* in the total input cost; and X_{jt} will be the input *j* in period t. In this specification, revenue shares for the output index and cost shares for the input index will be updated for each time period as compared to the use of fixed weights in the arithmetic and geometric indices. This help in avoiding the underestimation/overestimation issues implicit in a fixed-weight estimation procedure.

Macro Determination of Productivity Growth of Major Grain Crops

The classical regression analysis assumes that time series data are often non-stationary and thus the use of common statistical methods are not suggested. This fact becomes more important because most of the time series are trended over time which if regressed, may be spurious in nature [12]. Dealing with time series data, the first step is to test for unit root.

Unit Root Tests

Augmented Dickey-Fuller (ADF) test [8] and [9] is commonly used in time series econometric literature for testing stationarity and to make μ_t white noise. If Y_t is the data

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series (estimated TFP index of grain crops and other selected macro variables), ADF takes the following form.

$$\Delta Y_t = \alpha_1 + (\Phi_1 - 1) Y_{t-1} + \mu_t \quad (2)$$

$$\Delta Y_t = \alpha_2 + \beta_2 t + (\Phi_2 - 1) Y_{t-1} + \sum_{i=1}^{k} \Delta Y_{t-i} + \mu_t \quad (3)$$

Where μ_t are assumed to be identically, and independently distributed random variable. This test involves of adding unknown number of lagged first differences of the dependent variable to capture auto-correlated omitted variables that would otherwise enter the μ_t, error term. The ADF- test statistic also checks the null hypothesis that the time series has a unit root i.e. H_0: $(\Phi_2 - 1) = 0$ against the alternative hypothesis of stationary time series H_1: $(\Phi_2 - 1) \neq 0$. Joint hypothesis of unit root and no trend i.e. H_0: $(\Phi_2 - 1) = \beta_2 = 0$ can be tested, against the alternative hypothesis (H_1: $(\Phi_2 - 1) = \beta_2 \neq 0$) of trend stationary. This can be checked by using the Φ_2-statistic with critical values from Dickey and Fuller (1981).

Cointegration

Cointegration technique provides a useful way of identifying and avoiding spurious regressions generated by non-stationary series. Thus, basic idea is to identify equilibrium or long run relationships between variables. If a long run relationship exists between variables, then divergence from the long run equilibrium path is bounded, and variables are co-integrated. If this condition is fulfilled then it can be concluded that there exists an equilibrium relationship among a set of non-stationary variables, which would imply that their stochastic trends must be linked. An Error Correction Model (ECM) looks at this important relationship between change in the variable and deviation from the equilibrium. In this case, two conditions must be fulfilled; firstly, the series for at least two of the individual variables should be integrated of the same order. Second, linear combinations of the variables exist, which is integrated to an order lower than the individual variables. If variables become stationary after differencing once, they are said to be $I(1)$ and error term from the cointegration regression is stationary, i.e. $I(0)$ (Hansen and Juselius, 1995). Now consider the following cointegrating regression:

$$Y_t = \alpha + \beta X_t + \mu_t \quad (4)$$

Johansen Approach

[18] formulated a general framework for examining multiple cointegrating vectors, which allows the estimation of all possible cointegrating relationships, exists among the variables. The following Vector Autoregressive (VAR) model is basis of multivariate cointegration of Johansen Maximum Likelihood approach.

$$Z_t = A_1 Z_{t-1} + A_2 Z_{t-2} + \ldots\ldots + A_k Z_{t-k} + \mu_t \quad (5)$$

Where Z_t is an (n x 1) vector of $I(1)$ variable having both endogenous and exogenous variables, A_i is an (n x n) matrix of parameters, μ_t is (n x 1) vector of white noise errors. This equation can be estimated by Ordinary Least Square (OLS) because each variable in Z_t, is regressed on lagged values of its own and all other variables in the system. As Z_t is assumed to be non-stationary, the above equation can be written in its first difference or error correction form [7] as:

$$\Delta Z_t = £_1 \Delta Z_{t-1} + \ldots + £_{k-1} \Delta Z_{t-k+1} + \Omega Z_{t-k} + \mu_t \quad (6)$$

Where,

$£_1 = -(I - A_1 - A_2 - \ldots\ldots A_i)$, $(i=1,\ldots\ldots, k-1)$, and $\Omega = -£_1 = -(I - A_1 - A_2 - \ldots\ldots A_k)$

The above specification provides information about short-run and long run adjustments to changes in Z_t by estimating $£_1$ and Ω, respectively. Information about number of cointegrating relationship among variables in Z_t is given by rank of matrix Ω.

The model may have some variables which are $I(0)$ and are insignificant in long-run cointegrating space but effect model in short-run. Under this case, difference equation can be written as:

$$\Delta Z_t = £_1 \Delta Z_{t-1} + \ldots + £_{k-1} \Delta Z_{t-k+1} + \Omega Z_{t-k} + €D_t + \mu_t \quad (7)$$

Where D_t represents the $I(0)$ variable, which are often included to take account of short run shocks to system such as policy interventions. [18] described two likelihood ratio tests, trace and maximal eigenvalue tests, which provided the cointegration rank and estimate long run parameter matrix. The trace test is based on stochastic matrix and is defined as

$$\partial_{trace} = -2\ln Q = -T \sum_{i=r+1}^{k} \ln(1 - \partial_i) \quad (8)$$

The null hypothesis of this test is that number of distinct cointegrating vectors is less than or equal to r (i.e. no cointegrating vector) against alternative of r > 0 (i.e. one or more cointegrating vectors). The second test, which is called maximal-eigenvalue test, used for detecting the presence of a single cointegrating vector, is based on the following:

$$\partial_{max} = -2\ln(Q:r|r+1) = -T\ln(1 - \partial_{r+1}) \quad (9)$$

This statistic tests the null hypothesis that the number of cointegrating vectors is r against specific alternative (r+1) cointegrating vectors.

Error Correction Mechanism

Error Correction Mechanism (ECM) explains dynamics of short run adjustment towards long run equilibrium. The ECM specification is based on the idea that adjustments are made to get closer to long- run equilibrium relationship. Hence, link between co-integrated series and ECM is intuitive; an error correction behavior induces co-integrated stationary relationship and vice versa [20]. Let assume that X_t and Y_t variables are co-integrated, and the relationship between these two can be expressed as ECM. Assuming that X_t is the cause of Y_t and both variables are considered in logarithmic forms. The ECM can be written as:

$$DLX_t = \gamma_0 + \gamma_1 DLY_t + \gamma_3 ECT_{t-1} + \mu_t \quad (10)$$

Where, D represents first difference operator and μ_t is a random error term. The ECT_{t-1}, is one period error correction term from cointegrating regression. The equation stated that DLX_t depend on DLY_t and also on Error Correction Term (ECT). If the later is non-zero then the model is out of the equilibrium. Consider DLY_t is zero and ECT_{t-1} is positive, means that DLX_t is above its equilibrium value. Since γ is expected to be negative, the term $\gamma_3 ECT_{t-1}$ is negative and, therefore, DLX_t becomes negative to restore the equilibrium. This means that if X_t is above its equilibrium value, it will start falling in the next period to correct the equilibrium error [13].

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Econometric Model

The empirical framework employed in this study is based on the analysis of the TFP growth of grain crops (wheat and rice) in Pakistan. The macro variables which can effect total factor productivity growth of wheat and rice crops were broadly categorized into human capital development, credit resources, infrastructural development, openness of agricultural economy, macroeconomic stability, expenditures on agriculture and improved seed distribution. The following model has been developed in order to investigate the impact of different macro variables of economic and social concerns.

$$LTFP = f(LPSE, LRL, LCRD, LINF, LSXM, LAEXP, LISD) \quad (11)$$

Where:

LTFP = log of estimated total factor productivity growth of wheat and rice

LPSE = log of primary schools enrollment (thousand numbers), human capital proxy.

LRL = log of road length (thousand kilometers), proxy for infrastructural development.

LCRD = log of credit disbursed to wheat and rice crops as percent of agricultural GDP, proxy for financial/credit resources in agriculture.

LINF = log of inflation rate, proxy for macroeconomic stability.

LSXM = log of sum of grain exports and imports (000 MT), proxy for trade openness.

LAEXP = log of agricultural expenditure under five year and ten year perspective plans, proxy for expenditure as percentage of GDP.

LISD = log of improved seed distribution of wheat and rice crops (thousand tones).

FINDINGS AND RESULTS

The unit root test was performed by using software Microfit 4.1 [25]. The results of null hypothesis of non-stationary against the alternative hypothesis of stationarity are obtained by using Augmented Dickey-Fuller (ADF) test.

stationary after differencing once, said to be integrated of order one *I*(1). The unit root results in level form and first difference form have been presented in Table 1 and 2, respectively.

Cointegration and Error Correction Model

After testing the unit roots among the given time series data, the next step was to estimate cointegration. The present study used the Johansen's Full Information Maximum Likelihood (FIML) approach to estimate the cointegration. The first step in the Johansen's procedure was the selection of the order of Vector Autoregressive (VAR). Thus, in order to avoid over-parameterization, and also in the light of the statistics presented in Table 3, the order of VAR one (1) was selected.

The second step was to test the presence and the number of cointegrating vectors among the time series data in the model. The rank of the cointegration i.e. the number of the cointegrating vectors was selected by using the maximum Eigenvalues and the trace values test statistics. Results of both the tests revealed that there was one cointegrating vector in the data series, as the first statistic value for both the tests was greater than the 95 percent critical value (Table 4 and 5).

Johansen's Normalized Estimates

Unit Root Test Results

The unit root results showed that LTFP, LPSE, LRL, LAEXP, LCRD and LISD variables were non-stationary in the level form and become stationary after first differences. However, LSXM and LINF variables were found to be stationary in level form as suggested by two models. Thus in the light of the results, it was concluded that the data series on the variables, became

Cointegration analysis provides an improved method to estimate the long-run dynamic relationship among time series variables. The coefficients have been calculated by using equation (6). The variables *I*(1) were selected to explain the long-run relationship with grain crops TFP index. The results are presented in equation given below.

$$LTFP = 0.648LRL + 0.865LPSE + 0.758LCRD + 0.489LAEXP + 0.068LISD \quad (12)$$

Error Correction Model Estimates

The results of the ECM are presented in the Table 1.The model selected on the criterion of goodness of fit, data coherence, and consistency with the theory [15]. Different diagnostic tests as for the t-ratio tests of the coefficients, R^2 for goodness of fit, LM-test for serial autocorrelation, Ramsey's RESET-test for functional form misspecification, normality by the Jarque-Bera test and Hetroscedasticity test are also presented in the Table 6.

Table 1: ADF- Unit Root Results of the Selected Variables in Level Form

Variables	Non-Trended	Trended	Conclusion
LTFP	-1.73	-3.31	
LRL	-2.074	-0.61	
LPSE	-0.95	-1.65	
LCRD	-1.34	-1.64	
LINF	-3.68	-3.63	*I(0)*
LSXM	-3.04	-3.85	*I(0)*
LAEXP	-2.48	-2.48	
LISD	-1.35	-3.22	
C.V	**-2.94**	**-3.54**	

Source: Author's own calculations. Note: C.V is critical values for 5 percent significance level

Table 2: ADF- Unit Root Results of the Selected Variables in First Difference Form

Variables	Non-Trended	Trended	Conclusion
LTFP	-7.12	-7.02	*I(1)*
LRL	-4.26	-4.21	*I(1)*
LPSE	-4.39	-4.38	*I(1)*
LAEXP	-4.18	-4.20	*I(1)*
LCRD	-5.75	-4.78	*I(1)*
LISD	-6.85	-6.73	*I(1)*
C.V	**-2.94**	**-3.54**	

Source: Author's own calculations. Note: C.V is critical values for 5 percent significance level

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Table 3: Selecting the Order of VAR for Total Factor Productivity (TFP) Growth Model

List of Variables Included in the Unrestricted VAR:			
LTFP LRL LPSE LCRD LAEXP LISD			
List of Deterministic and/or Exogenous Variables:			
Constant LINF LSXM			
Order	**AIC**	**SBC**	**Adjusted LR Test**
4	224.5891	96.8574	_____
3	206.8529	108.5977	33.93786(0.567)
2	184.3049	115.5262	70.9164(0.514)
1	180.5017	141.1997	96.0552(0.788)
0	-37.3969	-47.4459	256.5533(0.000)

Source: Author's own calculations. AIC=Akaike Information Criterion. SBC=Schwarz Bayesian Criterion. ***Note:*** *p-values are in parenthesis*

Table 4: Cointegration Results for Total Factor Productivity (TFP) Growth Model

Cointegratig LR test based on maximum Eigen values of the stochastic matrix			
H0: (No Cointegration)	H1 (Cointegration)	Test Statistic	95 % C. Values
r =0	r =1	40.8522	40.5300
r <= 1	r = 2	30.7847	34.400
r <=2	r =3	21.6815	28.2700
r <=3	r = 4	14.7020	22.0400
r<=4	r=5	8.2239	15.8700
r<=5	r=6	5.8323	9.1600

Source: (Author's own calculations) Note: r is the number of cointegrating vectors

Table 5: Cointegration Results for Total Factor Productivity (TFP) Growth Model

Cointegratig LR test based on Trace values of the stochastic matrix			
H0: (No Cointegration)	H1 (Cointegration)	Test Statistic	95 % C. Values
r =0	r =1	119.0766	102.5600
r <= 1	r = 2	78.2245	75.9800
r <=2	r =3	47.4397	53.4800
r <= 3	r = 4	25.7582	34.8700
r<=4	r=5	10.0562	20.1800
r<=5	r=6	5.8323	9.1600

Source: (Author's own calculations) Note: r is the number of cointegrating vectors

Table 6 highlights the contribution of different macro factors to productivity growth of major grain crops and shows the estimates of long-run and short-run elasticities of variables included in the TFP growth model, along with their standard error, t-ratios and significance level. The signs of the estimated coefficients of all the variables were, according to *a priori* expectations.

The long-run elasticity of road length used as proxy variable for infrastructural development was 0.648 with a positive sign and was significant at 5 percent level. It implied that one percent increase in the road length increased productivity of major grain crops by 0.648 percent in the long-run. Short-run coefficient of the variable was 0.089, showing a positive sign, but was non-significant. Improved infrastructure, specifically roads, plays a vital role in improving the productivity as farmers can easily access to market for the sale of their product and as well as for the purchase of inputs. That increases the probability of timely marketing of the products and availability of resources that improves the technical efficiency of the farmers which ultimately lead to increased TFP of major grain crops. As such, infrastructural development helps to reduce the direct and indirect cost of production thus raising productivity growth. Investments in infrastructural development are long-term which shows its effect after certain time period and it's difficult to realize the returns in the short run.

The primary school enrollment, used as a proxy variable for human capital development showed a positive sign. The results indicated that one percent increase in the primary schools enrollment increased TFP of major grain crops by 0.865 percent in the long-run and only 0.03 percent in the short-run. In the long-run, the variable of primary schools enrollment was significant at 5 percent level of significance but insignificant in the short-run. The results of the variable showed that human capital improvement accounted for a significant contribution towards total factor productivity growth of major grain crops. By investing more in education, Pakistan can achieve a sustainable productivity growth of these grain crops.

The results also showed that one percent increase in agricultural credit disbursements to wheat and rice crops as percent of agricultural GDP, used as proxy variable for credit resources increased TFP of major grain crops by 0.758 percent in the long-run and 0.022 percent in the short-run. The sign of the coefficients explained the positive association between credit disbursement and TFP growth of major grain crops. However, the variable of credit was significant in the long-run and non-significant in the short-run. The positive impact of credit on total factor productivity was due to the fact that credit, found new areas of investment under efficient allocation of resources and this enhanced the productive capacity of these crops. Provision of credit facilitates the quality and timely availability of inputs that has got an important role in enhancing efficiency and productivity of these crops.

The results also showed that one percent increase in agricultural expenditure as percent of agricultural GDP, used as proxy variable for government expenditure on these crops increased TFP of major grain crops by 0.489 percent in the long-run and 0.069 percent in the short-run. The sign of the coefficients explained the positive association between research and development [23][29]. New areas of investment were found under efficient allocation of resources and this enhanced the productive capacity of these crops.

The results also showed that one percent increase in improved seed distribution of these grain crops TFP increased by 0.068 percent in the long-run and 0.049 percent in the short-run. The sign of the coefficients explained the positive association between improved seed disbursement and TFP growth of major grain crops.

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Table 6: Error Correction Model Estimates

Regressors	Short Run	S.E of Short Run Elasticities	Long Run	S.E of Long Run Elasticities
Constant			16.16 (2.015)**	8.021
DLRL	0.089 (0.363)^{ns}	0.246	0.648 (2.015)**	0.032
DLPSE	0.028 (0.256)^{ns}	0.110	0.865 (2.015)**	0.429
DLCRD	0.022 (0.775)^{ns}	0.029	0.758 (2.015)**	0.376
DLAEXP	0.069 (2.031)**	0.034	0.489 (2.015)**	0.242
DLISD	0.049 (1.022)^{ns}	0.048	0.068 (2.015) **	0.554
LINF	-0.020 (-1.643)*	0.012		
LSXM	0.033 (2.44)***	0.013		
ECM1(-1)	-0.064(-1.952)**	0.260		
R^2	0.586		**LM test**	0.542
D.W	1.90		**RESET test**	0.414
Jaeque-Bera Normality test	0.335		**Heteroscedasticity test**	0.998

Source: (Author's own calculations)

*Note: a) t-ratios are given in parenthesis. b) " * ", " ** " and " *** "indicates significances level at 10 percent, 5 percent and 1 percent, respectively. c) NS denotes the non-significances of the coefficients.*

d) by dividing long run elasticities with S.E, t-ratios were calculated.

However, the variable of improved seed distribution was significant in the long-run and non-significant in the short-run. The positive impact of this variable on productivity growth was due to the fact that improved seed distribution, increased productive capacity of these crops. Provision of improved seed distribution has got an important role in enhancing efficiency and productivity of major grain crops. The insignificance of this variable in the short run reflected the unawareness and reluctance to early adopt new seed varieties because ninety percent are small the farmers in Pakistan. They use last year's seed particularly of wheat and rice crops and store with traditional method and thus less productive in the next year. Inefficient and highly inequitable distribution of improved seed is also common in Pakistan. Most of the improved seed disbursed is directed towards the progressive and large farmers due to their greater access to agricultural institutions and private companies. Again improved seed distribution targeted towards small farmers failed to reach target groups [11]. However, in the long run, the relationship is significant as after some time period the improved seed made available to small and marginal farmers too.

The sum of the major grain crops exports and imports, used as proxy variable for openness of agricultural economy was positively associated with the productivity change of major grain crops. The coefficient of this variable was highly significant with a magnitude of 0.033 in the short-run, which implied that one percent increase in the sum of agricultural exports and imports increased TFP of major grain crops by 0.033 percent. As this variable was stationary at level form i.e. *I*(0), so it was included only in ECM to estimate its effect in the short-run. Openness of an economy also accelerates productivity growth through its effects of increased competition, access to trade opportunities on efficiency of resource allocation, positive externalities stemming from access to improved technology, accompanying knowledge spillovers, and access to essential production inputs from abroad. The results of inflation rate used as a proxy variable for macroeconomic stability indicated a significant negative effect on total factor productivity of grain crops. The elasticity coefficient of inflation rate was 0.020 with a negative sign. The results implied that one percent increase in the inflation decreased total factor productivity of major grain crops by 0.020 percent. The inverse relationship between inflation and total factor productivity of major grain crops might be due to the fact that high and unstable prices create economic uncertainties. This negative association might also be due to the fact that inflation encouraged capital flight which adversely affected the investment and hence total factor productivity growth. [22][28] explored that high inflation rates had negative impact on the rate of adoption of new techniques in the agriculture sector and hence adversely affecting the total factor productivity growth. [3] showed the significant adverse effect of inflation on agricultural output and productivity. He stated that most of the economists accepted the view that inflation is injurious to the health of economy and should be avoided.

The coefficient of the error correction term as shown in the Table 6 has a negative sign and tells about adjustment measures towards long-run equilibrium. The error correction term has the coefficient of -0.064 which was highly significant and showed that the deviation of productivity growth from the long-run equilibrium level was corrected by about 6 percent in a year. All the diagnostic tests provided satisfactory results. The LM-test indicated that there was no problem of serial correlation among the residuals. As the computed value was greater than 0.05, the null hypothesis of serial correlation among the residuals was rejected. The RESET-test also verified the correct functional form of the model. The Jarque-Bera test gave conclusion about the normal distribution of the residuals. The R^2 value of 0.586 indicated that about 59 percent variation in the total factor productivity in major grain crops was explained by the factors included in the model. Similarly Durbon-Watson statistics also verified the fact of no serial correlation among the residuals.

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RECOMMENDATIONS

Based upon the findings of the study, following recommendations are suggested;

- The results of the study showed a positive and significant relationship between education and total factor productivity growth of major grain crops in the long-run. The importance of education is beyond any doubt in uplifting the productive capacity of the farming community. Education of the labor force is important in increasing the efficiency of resource use and strengthening research for technological progress. On the basis of these findings it is recommended that investment in this sector can significantly enhance the productivity of major grain crops in the long-run. Budget allocation should be increased to enhance and sustain primary schools enrolment.
- The results of the study showed a positive and significant relationship between infrastructure and TFP growth of major grain crops in the long-run, advocating and justifying further investments in this sector on sustainable basis. Road network should be expanded to ensure the timely availability of inputs and easy access to the markets for these crop's products which will help in increasing the resource use efficiency and thus productivity. Better infrastructure attracts more domestic and foreign investments that will further increase productivity of major grain crops. Public private joint ventures may be a fruitful option in this regard. This will ensure sustainability of infrastructural developments in Pakistan.
- In this study the variable agriculture expenditure under five year and 10 year perspective plans was used to depict the impact of government spending on major grain crops (wheat and rice). This variable yielded positive and significant impact on the productivity growth of these crops which suggest that government should further expand investment on agriculture sector particularly for these crops to increase the productivity. Government should allocate more funds for research and development in these crops.
- Financial resources in major grain crops measured by the credit disbursement to major grain crops as percent of agricultural GDP showed positive association with productivity of wheat and rice crops. Thus in order to have a significant effect of credit on productivity, it is suggested that the small farmers should be provided an easy access to credit. Administrative hurdles should be eliminated and strict vigilance in the use of the credit be ensured. The field officers responsible for monitoring the activities of farmers should also be trained and motivated to ensure proper utilization of resources. This will help in fetching fair returns from the utilization of credit thus leading to improvement in total factor productivity of major grain crops.
- It is a well-known reality that openness stimulates growth of the agricultural economy including major grain crops. Thus, the expansion in the volume of agricultural trade should be the priority agenda of trade policy in Pakistan. It is recommended that major grain crops trade volume should be expanded through increasing the exports by keeping in view the domestic protection and food security scenario. Government should implement trade mark system in Pakistan. In this regard, to comply with above mentioned objectives, a more open and liberal trade policy should be the focus by the government. Trade barriers should be removed and new markets for the exports of major grain crops should be searched out. At the same time private sector should be motivated to comply with emerging requirements of trade liberalization.
- High rate of inflation is an important factor which adversely affects the purchasing power of the farming community and leads to misallocation and underutilization of the resources. This is also evident from the results by negative and significant impact of the inflation rate on total factor productivity growth of major grain crops. On the basis of the results, it is recommended that government should have complete check and balance on an artificial increase in the prices of inputs. This policy option will stabilize prices of agricultural inputs and technological intervention through continuous monetary and regulatory measures. This policy initiative will strengthen the economy and confidence of stakeholders in government policies and through multiplier effect, Pakistan may get numerous benefits through increasing productivity of major grain crops.
- The result showed that improved seed distribution had significant and positive impact on productivity of major grain crops. It is recommended that government should establish collaboration between federal seed certification department and private seed companies to enhance the distribution of improved seed of major grain crops. Private stores for seed distribution should also be established in rural areas.

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APPENDICES

Appendix 1: Total Factor Productivity (TFP) index of major grain crops 1971-2010

Years	TFP Growth Rate	Years	TFP Growth Rate	Years	TFP Growth Rate
1971	5.21	1985	-1.93	1999	-2.08
1972	9.29	1986	1.20	2000	0.6
1973	3.54	1987	-1.66	2001	0.83
1974	2.58	1988	-1.78	2002	-1.06
1975	-4.24	1989	-1.25	2003	-0.75
1976	-0.36	1990	2.38	2004	-6.07
1977	16.98	1991	-1.10	2005	1.72
1978	1.03	1992	-1.86	2006	4.40
1979	-11.19	1993	3.82	2007	-5.37
1980	-1.91	1994	4.06	2008	6.26
1981	6.21	1995	-3.75	2009	-1.12
1982	5.36	1996	0.12	2010	-0.44
1983	2.67	1997	21.25	**Total**	**49.88**
1984	-3.54	1998	1.85	**Average**	**1.25**

Source: Author's own calculations.

REVIEW REPORT

Review report of paper entitled "**Macro Determinants of Productivity Growth of Grain Crops (Rice and Wheat) in Pakistan: A Time Series Analysis"**

- Introduction is too long, shorten it with focus on the objectives of the study
- At page 2 line 4 , use the latest figures as per economic survey
- At page 2, second paragraph, use the latest data with reference
- At page 4, line 2, Add any reference.
- At page 6 , line 7 and 8 be deleted.
- At page 6, last line under heading openness of agricultural economy be deleted
- At page 7, add reference
- Page 10, Johensen approach need to shorten the description
- Page 17, description of error correction model too lengthy shorten it
- Page24, Only give the major findings, reduce the length of the paper