

## MACRO DETERMINANTS OF TOTAL FACTOR PRODUCTIVITY GROWTH OF AGRICULTURE IN PAKISTAN

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The role of productivity in accelerating the pace of economic growth is well recognized in the literature. With continual population growth, a diminishing supply of arable land, limits to further expansion of cultivated land and slowing returns to further input intensification, there is a growing need for productivity growth to expand food supply. The present study investigated the impact of different macro variables on Total Factor Productivity (TFP) of agriculture in Pakistan by employing cointegration analysis for the period from 1971 to 2006. The results indicated that human capital, infrastructure development and credit resources are positively associated with TFP of agriculture. Openness of the agricultural economy had a significant positive impact on productivity. Macroeconomic instability influenced TFP growth negatively and significantly. Real per capita income had a positive but insignificant relationship with productivity growth. Strong two way Granger-causality was observed between productivity and human capital development; and infrastructural development. Overall the results implied that policies which promote human capital, increase credit resources in agriculture, improve infrastructure development, facilitate openness of the agricultural economy, will improve the productivity and competitiveness of Pakistan agriculture.

### I. Introduction

The average annual growth of about 3.46 percent in Pakistan agricultural GDP over the last six decades has exceeded the population growth rate of about 2.58 percent. This growth rate in agriculture has been sustained by technological progress embodied in the high yielding varieties of grains and cotton, with supporting public investment in irrigation, agricultural research and extension, and physical infrastructure (Ali, 2005). Agricultural GDP growth, in turn, has made significant

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contribution to the overall economic growth of 5.03 percent per year during the same time period.<sup>1</sup> As in many other developing countries, agriculture in Pakistan faces considerable challenges. It is estimated that Pakistan will be the third most populous country in the world by the year 2050 (Ali, 2004). Such higher growth in population is a major constraining factor for achieving sustainable economic growth and food self sufficiency (GOP, 2011). Per capita income in Pakistan is also showing a rising trend. This increasing population pressure and higher per capita income is expected to increase the demand for food in future and any shortage of food in future will put the poor at high risk of survival. Thus with continual population growth, a diminishing supply of arable land, limits to further expansion of cultivated area, slowing returns to further input intensification and relatively high income elasticity of food in developing countries like Pakistan, there is growing need for productivity growth to expand food supply (Ali, 2004).

The present research tries to highlight the effect of public policies and other economic measures on TFP growth of agriculture in Pakistan. Analyzing total factor productivity of Pakistan's agriculture, using time series data is important for many reasons. The Pakistan government has implemented many wide ranging economic reforms since 1999- 2000. As these reforms have been implemented with different vigor in different sectors, agriculture being the main pillar of the national economy needs much more attention. It is important to know how these macro policy reforms have contributed in improving the productivity and competitiveness of agriculture in Pakistan.

The studies conducted regarding this subject have estimated total factor productivity by parametric as well as non-parametric approaches. In growth accounting framework, most of the studies used Tornqvist-Theil index number approach for TFP estimation. The literature showed a mixed trend in total factor productivity growth among developed and developing countries. Studies conducted in Pakistan regarding this subject as [Wizarat (1981); Rosegrant and Evenson (1993); Khan (1997); Ali and Byerelle (2000); Pasha et al., (2002); Sabir and Ahmad (2003); Ali (2004, 2005); Khan (2006); Ahmad and Bukhari (2007), and Kiani et al., (2008)]. Most of these studies had specifically focused only the role of research and development in Total Factor Productivity (TFP) growth. Sabir and Ahmad (2003), Khan (2006), and Ahmad and Bukhari (2007) have calculated total factor productivity growth of the economy as whole, giving little emphasis to agriculture sector. Most of the studies explained that the contribution of total factor productivity growth to agricultural output growth is more than 50 percent. It has been mentioned in the literature that different factors are responsible for total factor productivity growth of agriculture, and among them are the macroeconomic factors, directly or indirectly influencing the Total Factor Productivity (TFP) growth [Akinlo, (2005); Ray, (2012)]. Empirical studies regarding this aspect particularly for agriculture sector are missing so far in Pakistan.

The remainder of the paper is organized as follows: Section II presents the empirical framework; Section III discusses the empirical results, while Section IV concludes the study.

<sup>1</sup> The average annual growth rates of 3.46 percent, 2.58 percent and 5.03 percent in agricultural GDP, population and overall GDP, respectively have been calculated from the time series data on these variables, obtained from website of state bank of Pakistan (www.sbp.org.pk).

## II. Empirical Framework

### 1. Data and Variables Specification

Annual time series data in logarithmic form for the period 1971-2006 for all the variables described below had been collected from Pakistan Economic Survey, FAO statistical database, Handbook of statistics on Pakistan economy.

A set of macro variables, have been used in the literature for studying TFP growth of the economy. This study used macro variables particularly related to the agriculture sector that can be expected to effect directly or indirectly the TFP growth of this sector. The description of these factors contributing to TFP growth is given in the following sub-section.

#### • Human Capital Development

Human capital is often regarded as the accumulation of education, and educational change influences markedly productivity and economic growth. Investment in education promotes more skilled and specialized labor input. Since more skilled workers are better able to adjust in a dynamic, knowledge-based economy, and this result in enhanced productivity performance. Sharpe (1998) argued that with a stable macroeconomic environment, public support for training, education, and research and development enhances overall productivity of the economy. Pasha et al. (2002) emphasized the contribution of primary and secondary education in productivity growth. Khan (2006) used expenditure on education as a proxy for human capital development to investigate its impact on TFP of the economy. Akinlo (2005) and Njikam et al. (2006) used secondary school enrolment to capture the effect of education on TFP. Similarly Nachega and Fontaine (2006) stated that a well-educated and healthy work force directly or indirectly increases TFP and thus economic growth. They used average number of years of schooling of the labor force as a proxy for human capital accumulation. As the present study confines itself to TFP growth of the agriculture sector, the indicator of education expenditure used by Khan (2006) is perhaps too broad a measure of human capital. The present study used primary school enrolment in (000 numbers) 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 TFP. Extended infrastructure reduces the direct and indirect cost of production. Hazell and Fan (2002) stressed the importance of infrastructure in enhancing productivity in developing economies. It has been proved in many studies that the public investment on infrastructure in rural areas is playing the role of engine for agricultural productivity growth. Fan et al., (1999) explained that rural roads appear to be the important determinant while analyzing productivity growth of agriculture in India. Fan and Zhang (2004) also discovered the high importance of rural roads in productivity of rural areas in China. The present study used roads length in (000 kilometers) to specify infrastructural development variable.

- **Credit Resources**

Easy access to credit not only enhances economic growth but also the productivity of firms and contributes to TFP of the overall economy. Broadly speaking, it is the development of the financial sector that facilitates credit, necessary for healthy business and reflects positive relationship with TFP. Credit allows new areas of investment. Akinlo (2005) used credit as percent of GDP as an indicator of financial development. Nacheja and Fontaine (2006) used credit to GDP ratio as a proxy for credit resources. Njikman et al., (2006) used credit disbursement to the private sector as a proxy for financial depth. The present study used credit disbursement to the agriculture sector as a percent of agricultural GDP as a proxy for financial sector development in agriculture.

- **Openness of the 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 cheaper imported intermediate goods, larger markets, and advanced technologies that contribute to TFP growth.<sup>2</sup> In the literature, openness of trade is proxied as export to GDP ratio, or export plus import to GDP ratio, [Miller and Upadhyay, (2002); Akinlo, (2005); Khan, (2006); Nacheja and Fontaine, (2006) and Njikman et al., (2006)]. The present study used the sum of agricultural exports and imports as a percent of agricultural GDP as a proxy for the openness of agricultural economy.

- **Macroeconomic Stability**

Theorists and policy makers sometimes have conflicting views on the impact of inflation on growth and productivity. A positive relationship between inflation and TFP can be expected. On the other hand, inverse relationship between inflation and TFP can also be found. It might be that high and unstable prices create economic uncertainties and discourage investment. Inflation can also encourage capital flight which adversely affect the investment and hence TFP growth. Akinlo (2005) in a study on macroeconomic factors and total factor productivity growth in Sub-Saharan countries, used inflation as an indicator for macroeconomic stability. The present study used inflation rate (in percent) in the model to capture the instability in the economy, which is considered a necessary player for TFP growth.

- **Per Capita Income**

In Pakistan, non-farm income makes the larger proportion of the per capita income. The share of non-farm income in the per capita income in rural areas is about 59 percent, while the share of crop and livestock income is about 41 percent (Adams, 1993). Kamal (2006) also indicated that non-farm income represented the largest source of rural household income and had a favorable impact on income distribution. Thus per capita income does not purely reflect the income from agriculture production in Pakistan and there are many other sources contributing in per capita income. Per capita income of the country may contribute towards the

<sup>2</sup> Lewis (1980), Grossman and Helpman (1994), Miller and Upadhyay (2000, 2002), Akinlo (2005), Khan (2006).

increase in agricultural productivity through: 1) Increasing demand for food and other agricultural products. Income elasticity of demand for food is high in developing countries like Pakistan. That increase in demand may act as an incentive for farmers through change in price and farmers start making efforts for efficient utilization of the resources to increase their production; 2) Increase in per capita income improves the health and education level of the masses that, in turn, assume to have positive impacts on productivity through greater access to sources of information and better decision making; and 3) Increase in per capita income, especially in the rural areas may assure greater access to new technology at farm level which will add to agricultural productivity. Per capita income in Rupees, used to capture the direct or indirect effects of income levels of the masses on agricultural productivity growth. Nominal per capita income was transformed into real per capita income by GDP deflator (2000-01=100).

- **Total Factor Productivity Index**

The TFP index of agriculture in Pakistan has been estimated by Ali et al., (2009) and that estimated TFP index of agriculture was used as a dependent variable in the present study. A graphical presentation of input, output and TFP indices estimated by Ali et al., (2009) has been given in appendix 1.

## 2. Model Specification

To investigate the impact of different socio-economic variables on agricultural TFP growth, the empirical model is specified as:

$$LTFP = f(LPSE, LRL, LCRD, LINF, LSXM, LPCI) \quad (1)$$

Where;

- LTFP = log of total factor productivity index;  
 LPSE = log of primary schools enrolment (proxy for human capital development);  
 LRL = log of road length (proxy for infrastructural development);  
 LCRD = log of credit disbursed to agriculture sector as a percent of agricultural GDP (proxy for credit resources in agriculture);  
 LINF = log of inflation rate (proxy for macroeconomic instability);  
 LSXM = log of sum of agricultural exports and imports as a percent of agricultural GDP (proxy for openness of agricultural economy);  
 LPCI = log of real per capita income

## 3. Estimation Procedure

### 3.1 Testing For Unit Root

The present study begins by testing for the presence of unit roots in the individual time series, using the augmented Dickey-Fuller (ADF) test (Dickey and Fuller, 1981), both with and without a deterministic trend. The number of lags in the ADF-

equation is chosen to ensure that serial correlation is absent using the Breusch-Godfrey statistic (Greene, 2000). The ADF equation is estimated by OLS.

$$\Delta Y_t = \alpha_3 + \beta_3 t + (\phi_3 - 1)Y_{t-1} + \sum_{i=1}^k \theta_i \Delta Y_{t-i} + u_t \quad (2)$$

Where  $Y_t$  is the series under investigation,  $t$  is a time trend<sup>3</sup> and  $u_t$  are white noise residuals. It is not known that how many lagged values of the dependent variable to be included on the right-hand side of (2). There are several approaches but the present study used the Lagrange Multiplier (LM) test (Holden and Perman, 1994).

### 3.2 Testing For Cointegration

If two series are integrated of the same order, Johansen's (1988) procedure can then be used to test for the long run relationship between them. The procedure is based on maximum likelihood estimation of the vector error correction model (VECM):

$$\Delta z_t = \delta + \Gamma_1 \Delta z_{t-1} + \Gamma_2 \Delta z_{t-2} + \dots + \Gamma_{p-1} \Delta z_{t-p+1} + \pi z_{t-p} + \Psi x_t + u_t \quad (3)$$

where  $z_t$  is a vector of  $I(1)$  endogenous variables,  $z_t = z_t - z_{t-1}$ ,  $x_t$  is a vector of  $I(0)$  exogenous variables, and  $\pi$  and  $\Gamma_i$  are  $(n \times n)$  matrices of parameters with  $\Gamma_i = -(I - A_1 - A_2 - \dots - A_i)$ ,  $(i=1, \dots, k-1)$ , and  $\pi = I - \pi_1 - \pi_2 - \dots - \pi_k$ . This specification provides information about the short-run and long-run adjustments to the changes in  $z_t$  through the estimates of  $\hat{\Gamma}_i$  and  $\hat{\pi}$  respectively. The term  $\pi z_{t-k}$  provides information about the long-run equilibrium relationship between the variables in  $z_t$ . Information about the number of cointegrating relationships among the variables in  $z_t$  is given by the rank of the  $\pi$ -matrix: if  $\pi$  is of reduced rank, the model is subject to a unit root; and if  $0 < r < n$ , where  $r$  is the rank of  $\pi$ ,  $\pi$  can be decomposed into two  $(n \times r)$  matrices  $\alpha$  and  $\beta$ , such that  $\pi = \alpha\beta'$  where  $\beta'z_t$  is stationary. Here,  $\alpha$  is the error correction term and measures the speed of adjustment in  $\Delta z_t$  and  $\beta$  contains  $r$  distinct cointegrating vectors that are the cointegrating relationships between the non-stationary variables. Johansen (1988) uses the reduced rank regression procedure to estimate the  $\alpha$ - and  $\beta$ -matrices and the trace test statistic is used to test the null hypothesis of at most  $r$  cointegrating vectors against the alternative that it is greater than  $r$ .

### 3.3 Error Correction Mechanism

When the variables are cointegrated, there is general and systematic tendency for the series to return to their equilibrium value. It means that short-run discrepancies may be constantly occurring but cannot grow indefinitely. This shows that the adjustment dynamics is intrinsically embodied in the cointegration theory. The theorem of Granger representation states that if a set of variables is cointegrated ( $I, I$ ), it implies that the residual of the cointegrating regression is of order  $I(0)$ , thus there exists an ECM describing that relationship. This theorem explains that cointegration and ECM can be used as a unified theoretical and empirical frame-

<sup>3</sup> The rationale for having a trend variable in the model is that most of the series are trended overtime. So it is important to test the series for unit root having a stochastic trend against the alternative of trend stationary.

work for the analysis of both short-run and long-run behavior. The ECM specification is based on the idea that adjustments are made to get closer to the long-run equilibrium relationship.

Let assume that  $X_t$  and  $Y_t$  variables are cointegrated and the relationship between these two can be expressed as ECM. Assuming that the  $X_t$  is the cause of  $Y_t$  and both variables are considered in logarithmic form. The ECM can be written as:

$$DLX = \alpha_0 + \alpha_1 DLY_t + \alpha_2 ECT_{t-1} + \mu_t \quad (4)$$

Where  $D$  denotes the first difference operator and  $\mu_t$  is the random error term. The  $ECT_{t-1}$  is the one period error correction term from the cointegration regression. Equation (4) states that  $DX_t$  depends on  $Dy_t$  and also on the error correction term (ECT).

### 3.4 Granger-Causality Analysis

After establishing cointegration, the Engle and Granger (1987) error correction specification was used for testing of Granger Causality. If the series  $Y_t$  and  $X_{it}$  are  $I(1)$  and are cointegrated, then the ECM model is represented in the following form:

$$\Delta Y_t = \alpha_0 + \sum_{i=1}^n \beta_i \Delta Y_{t-i} + \sum_{i=1}^n \beta_j \Delta X_{it-i} + \delta ECT_{t-1} + \mu_t \quad (5)$$

$$\Delta X_{it} = \phi_0 + \sum_{i=1}^n \sigma_i \Delta X_{it-i} + \sum_{i=1}^n \sigma_j \Delta Y_{t-i} + \lambda ECT_{t-1} + \varepsilon_t \quad (6)$$

where  $\Delta$  is difference operator,  $\mu_t$  and  $\varepsilon_t$  are the white noise error terms,  $ECT_{t-1}$  is the error correction term derived from the long-run cointegrating relationship and  $n$  is the optimal lag length orders of the variables. The null hypothesis was constructed as  $H_0: X_{it}$  will granger-cause  $Y_t$ , if  $\mu_t \neq 0$ . Similarly,  $Y_t$  will granger-cause  $X_{it}$ , if  $\varepsilon_t \neq 0$ . For its implementation, F-statistics are calculated under the null hypothesis that coefficients of  $\mu_t$  and  $\varepsilon_t$  are equal to zero in the above equations. When the computed F-value is greater than the F-tabulated value, the null hypothesis was rejected, explaining the granger cause of one variable on the other.

## III. Empirical Results

### 1. Unit Root Results

The ADF- test was performed for testing the unit roots in the variables. The null hypothesis of the unit root were tested against the alternative hypothesis of stationarity including an intercept but not a trend and then including an intercept and a linear trend. Maximized log-likelihood (LL), Akaike Information Criterion (AIC), Schwarz Bayesian Criterion (SBC) and Hannan-Quinn Criterion (HQC) were used to determine the optimal lag length for the augmented terms. The computed absolute value of the test statistic was checked against the maximum values of these criteria



with the 95 percent absolute critical value for the ADF- statistic. When the computed absolute test statistic value was greater than the absolute critical value, the null hypothesis of a unit root was rejected which implied stationarity in the time series. On the other hand, when the absolute test statistic value was less than the absolute critical value, the null hypothesis of the unit root was accepted, implying that the series was non-stationary. The results are presented in Table 3.1.

**TABLE 3.1**

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

Variables	Non-Trended	Trended	$\phi_3$	Conclusion
LTFP	-0.41	-2.20	2.51	I(1)
LPSE	-0.37	-2.60	3.35	I(1)
LRL	-3.89	-3.32	2.67	I(1)
LCRD	-1.64	-1.61	4.53	I(1)
LINF	-3.97	-2.59	9.12	I(0)
LSXM	-2.82	-3.91	8.44	I(0)
LPCI	-0.37	-4.25	9.31	I(0)
C.V	-2.96	-3.57	6.73	

Source: Author's own calculations

Note: C.V is critical values for 5 percent significance level

Table 3.1 shows that the absolute computed values of the variables [(Total Factor Productivity index (LTFP), Primary Schools Enrolment (LPSE) and Credit Disbursed to Agriculture Sector as percent of Agricultural GDP (LCRD)], in the level form were less than absolute critical values (5 percent significance level), both for trended as well as for the non-trended models. The  $\phi_3$ -test also supported the results of the first two models, as the computed value was less than the critical value for the said variables. Thus the null hypothesis of a unit root was accepted and it was concluded that the above mentioned data series were non-stationary in the level form. The absolute computed value for the variable of Road Length (LRL) was less than the critical value for the ADF-statistic in the trended model but greater than the critical value in the non-trended model. The  $\phi_3$ -test was performed and the results indicated that the computed value was less than the critical value. Thus, two of three models suggested non-stationarity in the data series of road length and thus the null hypothesis of a unit root for the variable of road length was accepted.

The variables of Openness (LSXM), Inflation Rate (LINF) and real Per Capita Income (LPCI) were also analyzed for presence of unit root in level form. The

results indicated that absolute value of test statistic for the variable of Inflation Rate (LINF) appeared to be nonstationary in non-trended model. However, the other two tests (trended and  $\phi_3$ ) suggested that data series was stationary at its level form as the computed values were greater than the absolute critical values. Thus out of three models, two suggested the stationarity in the series of inflation rate, so the null hypothesis of unit root for this variable was rejected. Thus it was concluded that the variable of inflation rate (LINF) was stationary at the level form. The absolute computed value was less than the critical value in the non-trended model for the variables of Openness (LSXM) and real Per Capita Income (LPCI). The computed absolute value of the test statistic for the trended model for these variables in the level form was greater than the value for ADF- statistic. These results were also confirmed by  $\phi_3$ -test, which showed the stationarity in the variables of openness and per capita income. Thus the null hypothesis of the presence of a unit root was rejected for these variables and it implied that these variables were stationary at the level form. Thus these variables (LINF, LSXM, LPCI) were said to be integrated of order zero denoted by  $I(0)$ . The variables which were non stationary at the level form, analyzed again in the first difference form to check stationarity. All the series become stationary at their first difference form.

## 2. Cointegration Results

After testing for unit roots, the next step is to test for cointegration. The unit root results indicate that LINF, LSXM, LPCI series are  $I(0)$  i.e., stationary. These  $I(0)$  series cannot be used to investigate the long-run relationships between  $I(1)$  variables, but they can help explain the short-run behavior. Therefore they are allowed to enter the unrestricted VAR as exogenous variables. Johansen's procedure was applied to test the cointegration between the respective variables. The first step in Johansen's procedure is the selection of the order of Vector Auto Regressive (VAR). We use the LR-statistic, adjusted for small samples (Sims, 1980), to test the null hypothesis that the order of the VAR is  $k$  against the alternative that it is four where  $k=0, 1, \dots, 4$  and for all cases,  $k=1^4$ . The second step in the Johansen procedure is to test for the presence and the number of the cointegrating vectors among the series in the model. The rank of the cointegration i.e. the number of the cointegrating vectors was selected by using the trace values test statistics. The Johansen cointegrating results of the existence and number of cointegrating vectors among the series in the TFP growth model are presented in Table 3.2. The results show that first statistic value was greater than the 95 percent critical value. Thus on the basis of the results, the study rejected the null hypothesis of no cointegration and accepted the alternative hypothesis of the existence of cointegration. According to Harris (1995) the number of cointegrating vector is one when the null hypothesis is rejected for the first time. It can safely be said that there was one cointegrating vector among the series concerned.

<sup>4</sup> We also tried the Schwarz Bayesian Criterion (SBC) and Akaike information Criterion (AIC). Both SBC and AIC selects lag length one and four respectively. To avoid over-parameterisation, we choose one as the lag length (Pesaran and Pesaran, 1987).

**TABLE 3.2**

Co integration Results --- Trace Statistics

List of variables included in the cointegrating vector:			
LTFP	LPSE	LRL	LCRD
INTERCEPT			
List of I(0) Variables Included in the VAR:			
LINF	LSXM	LPCI	
H0: (No Cointegration)	H1: (Cointegration)	Test Statistic	95 % C. Values
r=0	r=1	53.895	53.4800
r<=1	r=2	28.577	34.8700
r<=2	r=3	10.759	20.1800
r<=3	r=4	2.127	9.1600

Note: r is the number of cointegrating vectors

In the Johansen model the parameters in the cointegrating vector can be interpreted as estimates of the long run cointegrating relationship between variables (Hallam and Zanoli, 1993) The estimated parameter values of equation (7), when normalized on the series of TFP index were the long-run elasticities.

$$LTFP = 0.64LPSE + 0.07LRL + 0.03LCRD \quad (7)$$

### 3. Error Correction Model Estimates Results

The error correction model results are reported in Table 3.3 and show that the signs of the estimated coefficients of all the macro variables accord with a priori expectations. The human capital development variable has a positive sign describing a positive relationship between TFP of agriculture and human capital. The results indicated that a one percent increase in primary schools enrolment (improvement in the educational capability of the labor force) increased TFP of agriculture by 0.64 percent in the long-run and by 0.03 percent in the short-run, although this was insignificant. Thus, human capital improvement accounted for a significant contribution and highlighted the importance of raising the human capital endowment of the agricultural labor force to achieve increases in TFP of agriculture.

The long-run elasticity of infrastructure development proxied by the road length was 0.07 with a positive sign. It implied that a one percent increase in the road length increased the productivity of agriculture by 0.07 percent in the long-run. The short-run elasticity of this variable was positive but insignificant with a magnitude of 0.01. The findings of this study are in accordance with previous studies. Evenson and Bloom (1991) observed a positive and significant impact of road length on productivity of Pakistan's agriculture in the long-run. Zhang and Fan (2001) found that

infrastructure development affects agricultural productivity in India in the long-run but not in the short-run. Fan et al., (2002) found that rural roads to be the important determinant for agricultural productivity growth in China.

**TABLE 3.3**

Error Correction Model Estimates

Regressor	Short-run		Long-run	
Constant			2.52	(1.95)
DLPSE	0.03	(0.20) <sup>NS</sup>	0.64	(4.44)*
DLRL	0.01	(0.04) <sup>NS</sup>	0.07	(1.91)**
DLCRD	0.05	(0.59) <sup>NS</sup>	0.03	(0.38) <sup>NS</sup>
LINF	-0.03	(-1.87)**		
LSXM	0.19	(1.82)**		
LPCI	0.06	(0.30) <sup>NS</sup>		
ECM 1 (-1)	-0.23	(-2.39)**		
R <sup>2</sup>	0.52		LM- $\chi^2$	0.062
D.W	2.14		RESET- $\chi^2$	0.937
Jarque-Bera	0.612			
Normality- $\chi^2$				

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

The results also explained that a one percent increase in credit resources increased TFP of agriculture by 0.03 percent in the long-run and 0.05 percent in the short-run, although both coefficients were non-significant. The insignificance of the credit variable in the present study might be due to an inefficient and highly inequitable distribution of agricultural credit. Most of the available credit was directed towards the large land holdings families exerting political influence. Another reason of the insignificance of this variable was the miss-utilization of credit and the administrative hurdles created during the provision of loans to farmers.

The openness of the agricultural economy was positively associated with the productivity change of agriculture. The coefficient of this variable was significant with a magnitude of 0.19 which implied that a one percent increase in the sum of agricultural exports and imports increased TFP of agriculture by 0.19 percent in the short run. The sign of the coefficient was according to a priori expectation because it

is generally believed that openness has a favorable impact on growth through increasing productivity. The fact is that more open economies can grow more rapidly through greater access to imported intermediate goods and advanced technologies that contribute to enhance productivity. The results for macroeconomic stability proxied by the rate of inflation indicated a significant negative effect on TFP of agriculture. The elasticity of inflation rate was -0.03, implied that one percent increase in the inflation decreased productivity of agriculture by 0.03 percent. The inverse relationship between inflation and TFP might be due to high and unstable prices creating a lot of economic uncertainties that discourage investment in agricultural related projects. This negative association might be also due to the fact that inflation encourages capital flight which adversely effected investment and hence TFP growth. The insignificance of the coefficient of real per capita income might be due to the fact that increases in per capita income are not equally distributed among the individuals in the country.

The coefficient of the error correction term has a negative sign which is according to the theory and it tells about adjustment measures towards long-run equilibrium. The error correction term has the coefficient of -0.23 which was highly significant, implies that the deviation of productivity growth from the long-run equilibrium level was corrected by about 23 percent in a year.

All other diagnostic tests provided satisfactory results. The LM-test indicated that there is no problem of serial correlation among the residuals. 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 R2 value of 0.52 indicated that about 52 percent variation in the total factor productivity in agriculture was explained by the factors included in the model. Similarly Durbin-Watson statistics also verified the fact of no serial correlation among the residuals.

#### 4. Granger Causality Analysis

The results of the causality analysis between Total Factor Productivity (TFP) and the various macro variables included in the model are presented in Table 3.4, using equations 5 and 6 described in the previous section. The regression was run separately for each of the explanatory variables which are of I(1) with the dependent variable (LTFP) including the error correction term. The first row shows the F-statistic value of 2.29 which was significant at the 10 percent level, while the second part of the first row was also significant at 4 percent. Thus, strong bi-directional causality could be concluded between productivity and development in human capital. These Granger-Causality results between human capital development and total factor productivity supported the evidence discussed in the previous section. Human capital development was a major determinant of Total Factor Productivity (TFP) growth of agriculture. The results also indicated that an increase in agricultural productivity promotes primary education.

The F-statistics for causality from credit availability to Total Factor Productivity (TFP) is 1.94 which was non-significant and the reverse of this also showed the same result. Thus the results found no causality between credit disbursement to agriculture and productivity growth and similarly between productivity and credit disbursement.

The causal relationship between infrastructure development and Total Factor Productivity (TFP) was again bi-directional. The F-statistic was significant at the 5 percent level in the case of causality from infrastructure development to productivity growth. A healthy infrastructure attracts new foreign and local investments which help to increase productivity. The causality from Total Factor Productivity (TFP) towards infrastructure was also highly significant which showed that a change in agricultural productivity caused a change in infrastructural development. More agricultural production increases GDP of the country and it enhances the resources at national level. Thus the governments invest more in the infrastructural development from the increased capital accumulation caused by the productivity of agriculture.

**TABLE 3.4**  
Granger-Causality Results

Causality	F-statistics	P-value	Direction
LPSE → LTFP	2.29	0.10	Bi-Directional
LTFP → LPSE	3.14	0.04	
LCRDI → LTFP	1.94	0.14	No-Direction
LTFP → LCRD	1.33	0.28	
LRL → LTFP	2.86	0.05	Bi-Directional
LTFP → LRL	3.47	0.02	

#### IV. Conclusions and Policy Recommendations

The present study was designed to investigate the impact of different macro variables (human capital development, infrastructure development, credit resources, openness of the agricultural economy, macroeconomic stability and real per capita income) on productivity growth of agriculture in Pakistan. In order to analyze this impact, a TFP index of Pakistan's agriculture, estimated by Ali et. al. (2009) is used as the dependent variable.

The results of analysis using cointegration and error correction models indicated that the magnitudes of the elasticity estimates are smaller in size in the short-run as compared to long-run for all the variables except credit disbursement. The study concluded that improvement in human capital and infrastructure development has a significant positive effect on TFP of agriculture in the long-run. The credit resources showed a positive but insignificant effect both in the long-run as well as in the short-run. The results also indicated that the openness of the agricultural economy and real per capita income was positively associated with TFP of agriculture. The openness of agriculture economy was found to be significant while real per



capita income was non-significant. The analysis also concluded that the inflation rate has a significant negative effect on productivity of agriculture in Pakistan. Overall the results showed that policies which promote human capital, increase credit resources, improve infrastructural development, facilitate openness of the agricultural economy and ensure macroeconomic stability; would lead to higher productivity growth in Pakistan's agriculture.

Based on the findings and research implications, the following policy measures/recommendations are suggested to improve total factor productivity of agriculture in Pakistan.

- 1) The importance of education is beyond any doubt in lifting 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. The coefficient of primary schools enrolment (proxy for human capital development) was positive and highly significant in the long-run which showed that education improves the human capital of the country and enhances the productivity of the labor force. The magnitude of the coefficient in the long-run was the largest (0.64) amongst all the variables. Thus the results strongly suggest that primary education should remain a priority agenda for the government and in this regard, specific steps should be taken to promote and fund basic education. Investment in this sector is expected to enhance productivity of agriculture significantly in the long-run.
- 2) Infrastructure is an important determinant in promoting the transition from traditional agricultural economies to market agricultural economies by increasing marketable surplus and reducing post harvest losses of agricultural commodities. The results of the study showed a positive and significant relationship between infrastructure and total factor productivity growth of agriculture in the long-run, advocating and justifying further investments in this sector on sustainable basis. The road network should be expanded to ensure the timely availability of inputs and easy access to the markets for agricultural products which will help in increasing the resource use efficiency and thus productivity. This will in turn ensure better returns to the farming community making them more productive. Better infrastructure attracts more domestic and foreign investments that will further increase productivity of agriculture. Government should focus on improving the access through roads particularly in remote and rural areas. Public private joint ventures may be a fruitful option in this regard. This will ensure sustainability of infrastructural developments in Pakistan.
- 3) Credit resources in the agricultural economy, measured by the credit disbursement to agriculture sector as a percent of agricultural GDP showed a positive association with total factor productivity although the coefficients were small and non-significant both in the long-run and in the short-run. Though the sign of the coefficient was according to a priori expectation, its non-significance may be due to the discrimination in its distribution and improper utilization. Thus in

order to have a significant effect of credit on productivity, it is suggested that small farmers should be provided with easy access to credit. Administrative hurdles should be eliminated and strict vigilance in the use of the credit should be ensured. It is also recommended that credit should be given to farmers in the shape of kind rather than cash to reduce the chances of its misutilization. Credit for mechanization in agriculture should be increased in order to capture its long-run impact on productivity. 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 achieving fair returns from the utilization of credit thus leading to improvement in total factor productivity.

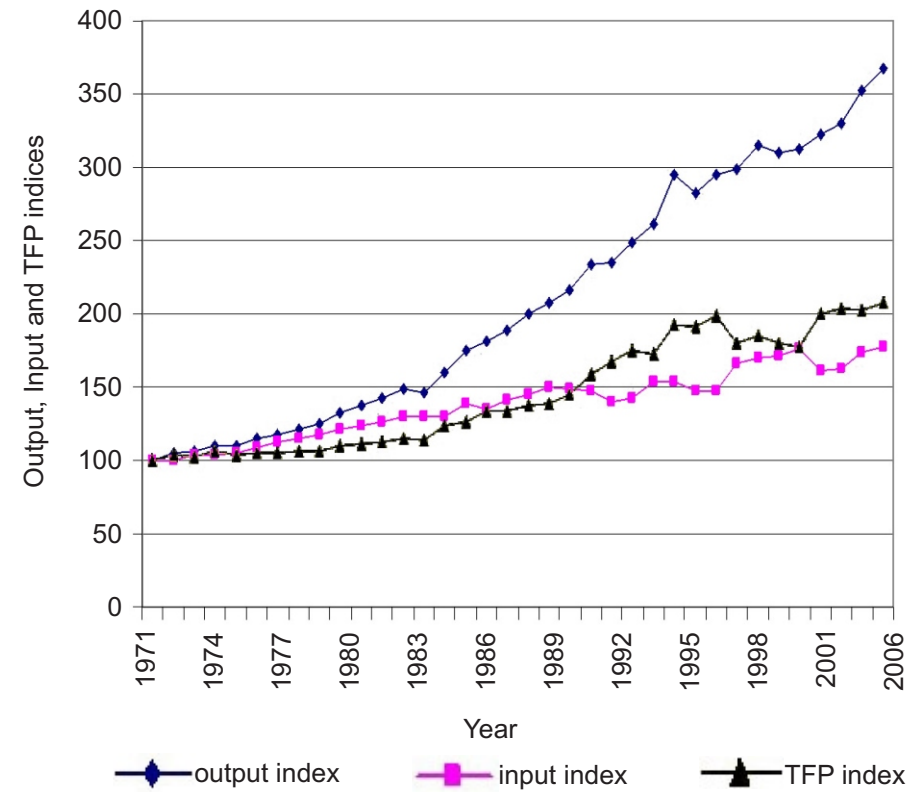
- 4) It is an established fact that openness stimulates growth of the economy including the agriculture sector. This factor becomes more important in the present scenario of trade liberalization. The coefficient of the sum of agricultural exports and imports as a percent of agricultural GDP (proxy for openness of agricultural economy) was 0.19 which was significant and largest next to primary schools enrolment (human capital development). Thus, expansion in the volume of agricultural trade should be the priority agenda of trade policy in Pakistan. It is recommended that agricultural trade volume should be expanded through increasing exports. This needs heavy investments in the agriculture sector to increase marketable surplus. Government should also adhere to the notion of trade liberalization by promoting further trade of agricultural commodities. In this regard, to comply with above mentioned objectives, a more open and liberal trade policy should be the focus of the government. Awareness should be created among the farming community in adopting and imitating technology that trickles through trade. It is also strongly recommended that the optimal share from agricultural exports should be transferred to farmers in order to create incentive to enhance productivity. Trade barriers should be removed and new markets for the exports of agricultural commodities should be searched out. At the same time the private sector should be motivated to comply with emerging requirements of trade liberalization. In addition more diplomatic efforts are also needed to develop a good image for Pakistani products in the international market.
- 5) A 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 resources. This is also evident from the results which show a negative and significant impact of inflation rate on total factor productivity growth of agriculture. On the basis of the results, it is recommended that government should adopt contractionary monetary policy on the one side and productive utilization of resources on the other side to control inflation. This policy option will stabilize agricultural prices of 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 the multiplier effect, Pakistan may get numerous benefits through increasing productivity of agriculture.



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## APPENDIX A



Source: Graph has been reproduced from Ali et al., (2009)

**FIGURE 1**  
Output, Input and Total Factor Productivity (TFP)  
Indices of Pakistan's Agriculture: 1971-2006

The above Figure shows that the output index was set to 100 in the base year i.e. 1971 and it approached approximately 368 in the last year of study period. While the series of the input index also started from 100 in the base year and reached to the figure of about 177 in thirty six years of the study period. As for as the estimated total factor productivity index of agriculture in Pakistan is concerned, it touched the number of about 208 during the study period, again started from 100 in the year 1971. These indices clearly depicted that increase in the agricultural output index was maximum, while increase in the agricultural aggregate input index was minimum. This gap was bridged by the increase in total factor productivity of agriculture, lies between output and input indices.