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Impact of Social and Physical Infrastructure on Agricultural Productivity in Punjab, Pakistan-A Production Function Approach

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Abstract

In agricultural based countries, public investment on rural infrastructure not only increases agricultural productivity but also reduces poverty. This study attempted to quantify the impact of public infrastructure (both social and physical) investment on total factor productivity (TFP) in Punjab, Pakistan using the multivariate Cobb-Douglas production function for the period 1970-2005. The results showed that public investment on physical infrastructure (rural roads, village electrification and irrigation) and social infrastructure (rural education and rural health) have contributed significantly and positively to TFP. The study suggested that more resources should be diverted towards the development of physical and social infrastructure that will enhance the agricultural productivity as well as reduce the rural poverty.

Keywords: Social infrastructure, Physical infrastructure, TFP, Cobb-Douglas

Introduction

In developing countries like Pakistan, public investment is one of the sharpest instruments through which the government can achieve its development objectives. Among different investments, infrastructure investment both social infrastructure (education and health) and physical infrastructure (roads, electrification, research and development, irrigation, market development etc) plays a vital role in enhancing agricultural productivity and reducing poverty in a country wherein majority of the population directly or indirectly depends on agriculture. In Pakistan, where structural transformation process is in progress, agriculture sector is still the single largest sector of the economy with deep influence on socio-economic set up.

Empirical studies of Haggblade et al. (1991) and Fan et al. (2000) have concluded that the multiplier effect of agricultural growth is usually greater than two. According to Mellor (1976), the multiplier effect appears more when agricultural growth is driven on account of productivity increased. Growth in both the tradable and non-tradable sectors of agriculture stimulates strong growth in other sectors of the economy via multiplier effects. Hence, in future, the growth strategy for most agriculture-based economies has to be affixed on getting agriculture moving (World Bank, 2008).

Agriculture in Pakistan is a source of the livelihood of almost 45 percent of the total employed labour force in the country. Present contribution of Agriculture towards National GDP stands at 20.9 percent. No strategy of economic development can be successful without giving due importance to this sector because it has strong forward and backward linkages particularly with the industrial sector (GOP, 2011).

The contribution of Punjab agriculture sector is 28 percent to the provincial gross domestic product and accounts for over 40 percent of total employment in the province. Punjab crop sector contributes about 68 percent to total food grains production in the country. The province is also a major contributor towards country's exportable surplus which usually comes from agriculture sector. Despite of these facts, yield gaps are quite high in Punjab. The yield in Punjab of selected crops is 50 to 83 percent lower than the highest averages attained in other countries of the world. Closing the yield gaps thus offers significant prospects for future agricultural growth in Punjab. There are number of reasons for the presence of large yield gaps in Punjab including low investments on research and extension, irrigation, rural roads, education, health and rural electrification infrastructure (GOPB, 2007). Therefore, in order to achieve the goals of overall economic uplift and poverty reduction, sustained growth rate in agriculture is essential (Kiani et al., 2008).

Various studies have estimated the relationship between productivity and different public sector investments variables. Shane et al. (1998) explained that due to large number of producers and the dispersed nature of production, public investments

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had been a very important source of productivity growth for agriculture. They estimated that public agricultural research and development (R&D) and infrastructure account for 75 percent of the growth in agricultural productivity between 1949 and 1991. Fan et al. (2000) explored that in order to reduce rural poverty; the Indian government should give highest priority to additional investments in rural roads and agricultural research. According to them these types of investment have larger impact on productivity growth and poverty reduction than any other public investment. They also revealed that government spending on education has the third largest marginal impact on rural poverty and productivity growth. Other investments such as irrigation, soil and water conservation, health, and rural and community development has only modest impacts on growth and poverty per additional rupee spent.

According to Fan et al. (2002) government spending on production-enhancing investments, such as agricultural research and development (R&D), irrigation, rural education, and infrastructure (including roads, electricity, and telecommunications) all contributed to agricultural productivity growth and reduce regional inequality and rural poverty in China. They also found that government expenditure on education has the largest impact on poverty reduction and very high returns to growth in agriculture and rural economy as a whole. Mamatzakis (2003) calculated a model of Greek agriculture's technology and behavior by dual cost function approach by using the data of 1960-1995. The empirical estimates indicate that public infrastructure investment provide significant returns to agriculture and productivity growth. Fan et al. (2004) illustrated that despite Thailand's middle income status, most government investments such as agricultural R&D, irrigation, rural education, and infrastructure (including roads and electricity), has positive marginal impacts on agricultural productivity growth and rural poverty reduction. Bloom et al. (2004) found that life expectancy and schooling have a positive and significant effect on GDP by using 2SLS technique. Improvements in health increase output not only through labour productivity, but also through the Capital accumulation. Study also revealed that improvement of one year in a population's life expectancy resulted into an increase of 4% in output. Cole and Neumayer (2006) estimated the impact of poor health indicators that are particularly problematic in developing regions (malnutrition, malaria and waterborne diseases) and revealed that impact of poor health on TFP to be negative, significant, and robust across a wide variety of specifications. Malik (2006) explained that if OLS is used then there is no significant relationship between health status and economic growth. However, when 2SLS is used then study finds highly significant effect of health indicators (infant mortality rate, life expectancy rate and crude health rate) on economic growth in India. Ashok and Balasubramanian (2006) examined the role of infrastructure on total factor productivity in India. The results of the study clearly establish that the investments in rural infrastructure like roads, irrigation, rural markets, and rural literacy increase the total factor productivity in Tamil Nadu agriculture.

Limited empirical work is found in Pakistan as regard the relationship between agricultural productivity and public investment. According to Rosegrant and Evenson (1993) agricultural research, high yielding varieties (HYVs), literacy, and share of irrigation are the major sources of total factor productivity growth. Pasha et al. (2002) quantified the contribution of different factors to growth of total factor productivity both for the individual sectors and for the economy as a whole. They examined the role of different factors in influencing the level of TFP of agriculture in Pakistan on a long-term basis for the period of 1972-73 to 1997-98. They concluded that human capital improvement accounts for 1.6 to 1.8 percent annually in total factor productivity and TFP can be increased by investing more in education, especially at the primary and the secondary level. Akram et al. (2009) investigated the impact of different health indicators on Economic growth in Pakistan. They concluded that impact of health is only a long run phenomenon because no significant relationship between health and economic growth was seen in the short run. Kiani et al. (2008) evaluated the impact of different investments on total factor productivity in Punjab using Almon distributed lag model. The study concluded that besides research expenditures, roads, number of tractors, and tube wells showed positive and significant impact on TFP in the crops sub-sector.

In Punjab, only few studies have been done in the area of public spending in agricultural productivity. However, there is little or no quantitative evidence of public spending on social (education and rural health) and physical infrastructure like village electrification with respect to their impact on agricultural total factor productivity is seen in empirical literature. So in this regard, this will be a useful contribution in the empirical literature and for the policy makers in future. The main objective of this study was to examine the relationship between the public spending on physical infrastructure and social infrastructure and total factor productivity in the province because TFP is conceptually superior measure to study the impact of infrastructural variables, as it explains the

growth in output which is not explained by the growth in the traditional inputs.

Materials and Methods

In order to analyze the relationship between investment variables and total factor productivity, we use Cobb- Douglas Production function.

$$TFP_t = AW_t^{\gamma} \prod_{j-1}^{k} X_j^{\beta_j} . e^{\mu} \quad (1)$$

In log form of our model would be as under:

$$\ln TFP_t = \ln A + \ln W_t + \beta_{1t} \ln X_{1t} + \beta_{2t} \ln X_{2t} + --- \beta_{nt} \ln X_{nt} \quad (2)$$

However, the linear form of our model would be

$$\ln TFP_t = \ln A + \ln W_t + \sum_{i=1}^{n} \beta_{it} \ln X_{it} + \mu_t \quad (3)$$

Where

TFP_t = is aggregate Total Factor Productivity of Punjab's crop and livestock sub-sectors.

X= represents investment variables of physical infrastructure, social infrastructure and agriculture.

W= is a dummy variable representing weather effect.

Data

Data sources and description is presented in Table 1. Data on rural education, agriculture, irrigation and rural health includes both development and non development expenditures while data on rural roads comprises of only development expenses and data on all variables except village electrification were taken from various copies of Annual Development Plans and Budget copies, Government of the Punjab, Pakistan. The data on village electrification are taken from various copies of Punjab Development Statistics. To make real, the data has been deflated by the GDP deflator by taking 2000-01 as base year.

Results and Discussion

Summary statistics of the model showing mean and Standard Deviation of the variables is presented in Table 2. The mean of all the variables except DM is found hovering around 5 while Standard Deviation of all the variables except variable RHE (-5) is below 0.5.

We estimated the model (3) which is linear in logarithms and results are presented in Table 3. The signs of the coefficients are according to *a priori* expectations in the model.

The results indicated that the coefficient of variable RHE (-5) is significant at 1% level of significance. The highest impact of the variable is observed at lag 5. Our result also get support from the result of Akram et al. (2009) who concluded that impact of health is only a long run phenomenon. The value of coefficient illustrates that a 1 percent increase in the investment on social infrastructure, increases TFP by 0.13. The results of this study are conforming to other studies e.g., Fan et al. (2002, 2004), Shakeri (2004) and Pasha et al. (2002). The calculated elasticity of the variable (RVRI) was 0.24 which is highly significant. Thus a 1 percent increase in the investment on physical infrastructure such as rural roads, irrigation and village electrification increases TFP by 0.24 percent. This result supports other studies such as Leinbach (1983) who concluded that rural road development contributed to higher productivity. Binswanger et al. (1993) and Ashok and Balasubramanian (2006) found that easier access to markets, technology and better roads raised farm and non-farm production by providing accessibility to relevant inputs at lower cost. Fan et al. (2000) revealed a positive and significant impact of rural infrastructure investment on TFP. Moreover, the increasing use of technology during Green Revolution played an important role in boosting agricultural production and productivity in Pakistan and the province of Punjab. The assured irrigation water through installation of electric tube wells and canals is one the essential elements in enhancing productivity in the country. Kiani et al. (2008) found a positive and significant impact of tubewells on TFP in crop sub-sector in the province of Punjab, Pakistan, Shakeri (2004) concluded that investment on rural infrastructures, road, agriculture R&D, irrigation, rural education, electrification etc. are prior conditions of rural-agricultural sector development and Fan et al. (2002, 2004) also observed a positive marginal impact of electrification and other investment variables on agricultural productivity growth and rural poverty reduction. The estimated coefficient of agriculture (AGRI) variable is 0.21. Hence, a 1 percent increase in investment on agriculture increases TFP by 0.21 percent. No strategy of economic development can be successful without giving due importance to this sector as it has forward and backward linkages particularly with the industrial sector (GOP, 2011). Dummy variable which represents the weather effect also disclose its significance effect on TFP.

The Durbin-Watson (DW) statistics imply that there is no serial correlation in the model. Time series analysis often confronts a problem of multicollinearity among regressors of a model. In case of high multicollinearity, the authenticity of results becomes less reliable. In order to check multicollinearity different criteria have been suggested including Variance Inflation Factor (VIF) and Eigenvalues (Gujrati, 2003). Table 4 presents the Collinearity Statistics among the independent variables of the model. The results of the table imply that there exists no problem of multicollinearity.

Table 1 Variables Description and Data Sources

Variables	Description
TFP	Punjab's Total Factor Productivity which is estimated by taking both agriculture and livestock sub-sectors for the period of 1970-2005 and has been taken from Nadeem et al. (2010).
RHE	Expenditure on rural health and education. The expenditure data on rural health and rural education is not readily available from literature. However, it is estimated from expenditures on primary education and expenditure on health in the province on the basis of percentage share of rural population in the total population of the Province of Punjab. The data on data on primary education and health was obtained from various issues of Annual Development Plans and budget copies.
RVRI	Expenditure on rural roads, irrigation infrastructure and number of village electrified in the province. Data on rural roads are available only for 1985-2005. To derive expenditure on rural roads, data for 1970-1984 are extrapolated on the basis of the percentage share of the rural roads in the total provincial roads. Expenditure on rural roads is calculated as per kilometer expenditure multiplied by one fifth of the expenditure on total rural road length that is we assume that cost per unit of rural roads is one fifth that of urban roads. Data on expenditure on irrigation infrastructure and village electrified are collected from various copies of Development Plans, Budget Copies and Punjab Development Statistics, Government of the Punjab.
AGRI	Aggregate expenditures on crop and livestock sub-sectors in the Province of Punjab. The data were collected from both annual development plans and budget copies of the province.
DM	Dummy variable to capture the influence of weather, floods etc. DM takes the value of unity for the years 1970, 1971, 1973, 1974, 1983, 1993, 2000, 2001, 2003, 2005 and zero otherwise.

Note: All variables except DM are used as index variables in the model.

Table 2 Summary Statistics of the Model

Variables	Mean	Std. Deviation
TFP	4.98	0.21
RHE (-5)	5.88	0.68
RVRI	5.29	0.27
AGRI	5.38	0.36
DM	0.23	0.43

We estimate the model (3) which is linear in logarithms and results are presented in Table 3. The signs of the coefficients are according to *a priori* expectations in the model.

Table 3 Regression Results of Public Investments on Total Factor Productivity in Punjab, Pakistan

Variables	Coefficients
Constant	1.84 (7.99)* [0.00]
RHE (-5)	0.13 (4.78)* [0.00]
RVRI	0.24 (5.10)* [0.00]
AGRI	0.21 (4.46)* [0.00]
DM	-0.04 (-1.99) ** [0.06]
R-square	0.959
Adjusted R-square	0.953
DW-Statistics	2.00

*, ** show significance at 1 and 5 percent, respectively; Values in parenthesis are t-ratios while values in Brackets are p-values

Table 4 Collinearity Statistics of Public Investment Variables

Variables	Variance Inflation Factor VIF)	Eigenvalue
RHE (-5)	5.23	0.001
RVRI	2.25	0.006
AGRI	4.20	0.0004
DM	1.23	0.71

Summary and Conclusions

This study attempted to quantify the impact of public infrastructure (both social and physical) investment on total factor productivity (TFP) in Punjab, Pakistan using the multivariate Cobb-Douglas production function for the period 1970-2005. The results showed that, public investment on social infrastructure, physical infrastructure and agriculture have contributed significantly and positively to total factor productivity. The tests of autocorrelation and multicollinearity also confirmed that there was no problem of autocorrelation and multicollinearity in the model.

According to World Bank (2008), the growth originating in agriculture is four times more effective in reducing poverty than the growth coming from non-agriculture sectors. The results of the study suggest that investment in both social and physical infrastructure will enhance agricultural productivity in the province. The increase in agricultural productivity will further reduce the rural poverty by improving the socio-economic conditions of a large segment of rural population which directly or indirectly involved in agricultural related activities and would ensure food security. The results illustrate that investment on physical infrastructure has the largest impact on agricultural productivity. Low

investment on rural roads and irrigation can be a major impediment towards enhancing productivity and improving the socio-economic conditions of the farmers due to weak linkages between rural and urban markets, high transportation cost and non availability of inputs at proper time and shortage of irrigation water etc. Hence, the study suggested that more resources should be diverted towards physical infrastructure. However, the importance of social infrastructure can not be neglected. Primary education especially rural primary education may affect the productivity through technical efficiency of farming community. To the best of our knowledge there exists no study which has evaluated the impact of rural health investment on TFP in Punjab agriculture sector. The study also suggested a due share of investment on rural health in the province because most of the rural population deprive of health facilities at their door step. Proper availability of health facilities at village level will not only provide a sense of mental satisfaction but also reduce their expenses on health and will save their precious time by taking a patient to the nearest hospital in the city.

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