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TRENDS IN TOTAL FACTOR PRODUCTIVITY IN PAKISTAN AGRICULTURE SECTOR

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Abstract. Total factor productivity (TFP) has emerged as an important source of agriculture growth. However, this area remained neglected by researchers as well as policy makers in Pakistan. The studies which have estimated agriculture TFP growth in Pakistan are very few and they have tended to overstate it by ignoring the variation in capacity utilization, hours worked and improvement in labour productivity as a result of increased level of education and training. The present study has avoided this pitfall and has accurately measured TFP growth. According to this study, agriculture TFP in Pakistan has grown at an annual average rate of 0.28 percent which explains more than 7 percent of the growth of agriculture value added. The study recommends that TFP should be given proper attention by the government. Appropriate policy, such as diffusion of relevant information among the farmers, increased area under cultivation, and timely availability of fertilizer at affordable prices for the farmer, should be devised to accelerate TFP and value added growth in the agriculture sector of Pakistan.

I. INTRODUCTION

Agriculture is an important sector of Pakistan economy. It provides living to 66 percent of population of the country. Besides, it accounts for 21 percent of GDP, absorbs 43.4 percent of employed labour force, and contributes 11 percent to export earnings.[1] As such, agriculture growth is very crucial for economic growth in Pakistan. Agriculture sector supplies raw materials to manufacturing sector. It also provides market for manufactured products.

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[1]*Pakistan Economic Survey 2006-07*.

During the period 1950-2004 agriculture value added grew at an annual average rate of 3.6 percent which has exceeded the average population growth rate of 2.9 percent during this period.[2] Various factors have signify-cantly contributed to the growth of agriculture. Among these, the most important are technological progress embodied in high-yielding varieties of food grain and cotton, public sector investment in agriculture, research and extension expenditures (R&E) and physical infrastructure. Although agriculture sector growth has significantly contributed to the growth rate of GDP of 5 percent during this period, however, its own performance has shown violent behaviour over time. Table 1 provides trends in growth rates of value added in agriculture sector of Pakistan. On one hand, agriculture value added grew at a meagre rate of only 1.8 percent during the 1950s. On the other hand, it showed a respectable rate of growth of 5.12 percent during the 1960s. In other periods its growth remained between these limits.[3]

TABLE 1

Growth Rates of Agriculture Sector (Decadal Averages)
(Percent)

Period	Growth Rate	Share in GDP
1950s	1.76	47.70
1960s	5.12	40.68
1970s	2.32	34.50
1980s	4.10	27.62
1990s	4.54	25.34
2001-05	3.38	24.25
1951-2005	3.55	34.36

Source: *50 Years of Pakistan in Statistics*, Volume I, Summary and Pakistan Economic Survey, Various Issues.

The sources of agriculture value added growth include, among others, the growth of inputs such as labour, capital and area under cultivation. Apart

[2]Calculated by the present authors using data from *Pakistan Economic Survey*, 2004-05 and *50 Years of Pakistan in Statistics*, Volume I, Summary, Government of Pakistan.

[3]These figures are calculated by the authors using data from *50 Years of Pakistan in Statistics*, Volume I, Summary and Pakistan Economic Survey, Various issues.

from these, there is another important source of agriculture value added growth. This source is total factor productivity (TFP). TFP is also an important contributor of value added in the agriculture sector. The fluctuations in TFP cause fluctuations in agriculture value added. Thus, there is a compelling need to capture the fluctuating trends in TFP growth in the agriculture sector. The main objective of this paper is to estimate TFP growth in agriculture sector of Pakistan. The rest of the paper is organized as below: In section II, a review of existing studies on agriculture TFP growth is presented. Section III presents the methodologies and sources of data used for the estimation of TFP. In section IV measurement of variables is discussed. Estimation of results is presented in section V. Finally, section VI contains conclusion and policy implications and recommendations.

II. REVIEW OF PREVIOUS STUDIES

There have been very few studies estimating TFP growth for the agriculture sector of Pakistan. The pioneering among these is the study by Wizarat (1981). She used annual time series data for the period 1953-1979 to estimate arithmetic TFP index in the growth accounting framework. According to her estimates TFP growth in the agriculture sector of Pakistan remained at 1.1 percent. Ali (2004) has pointed out various limitations of her study.[4]

Evenson and Pray (1991) used cross-section district-wise and annual time series data to estimate Tornqvist-Theil approximation to the Divisia index over the period of 1965-85. Their estimate of average annual growth of TFP was 1.07, *i.e.* slightly less than that of Wizarat (1981). Rosegrant and Evenson (1992) also found the same estimates of TFP based on T-T index over the period 1957-85 as found by Evenson and Pray (1991). However their estimates for sub-periods greatly varied (see Table 2). Khan's (1994) estimate of TFP growth based on Arithmetic index over the period 1980-93 was 2.1 percent. However, in his (1997) study when he used T-T index and extended the sample over the period 1960 to 1996 his estimate of TFP growth sharply fell to 0.92 percent. Kemal *et al* (2002) employed arithmetic index in the growth accounting framework to estimate TFP over the period 1964-65 to 2000-01. Their estimate of annual average growth rate of TFP was only 0.37 percent. Ali (2004) calculated both the arithmetic index and T-T index over the period 1960-96. His estimate of TFP growth based on arithmetic index was 2.17 percent when 1960-61 weights were used. When

[4]The study assumes linear production function which implies perfect substitutability between labour and capital. Capital input has been used as a stock variable whereas the more appropriate is the concept of service flow.

he changed the weights to 1980-81 the estimate of TFP drastically fell to only 0.40 percent. The estimate of TFP growth based on T-T index was 2.3 percent.

A common limitation of these studies is their inability to adjust the capital stock for variation in its utilization and the labour force for improvement in its skill resulting from increased level of education and training. The present study is free from this shortcoming.

TABLE 2

Total Factor Productivity Growth in Agriculture Sector of Pakistan: 1953-96

Study	Period of Study	Estimation Methodology and Nature of Data	Average Annual TFP Growth Rate (Percent)
Wizarat (1981)	1953-79	Arithmetic index / Annual time series	1.1
Evenson and Pray (1991)	1956-85	T-T index / Cross-section district-wise / annual time series	1.07
Rosegrant and Evenson (1992)	1957-85	T-T index / annual time series	1.07
	1957-65		1.65
	1965-75		1.86
	1975-85		–0.36
Khan (1994)	1980-93	Arithmetic index / annual time series	2.1
Khan (1997)	1960-96	T-T index / annual time series	0.92
Kemal *et al.* (2002)	1965-2001	Arithmetic index / annual time series	0.37
Ali (2004)	1960-96	Arithmetic index / (Weights 1960-61)	2.17
		(Weights 1980-81)	0.40
		T-T index / annual time series	2.3

III. METHODOLOGY AND SOURCES OF DATA

METHODOLOGY

In the growth literature, since Solow (1956), the growth accounting method is most widely used. We have used this method for the estimation of total factor productivity of agriculture sector of Pakistan. This method for the estimation of TFP became popular due to the work of Kendrick (1961) and Denison (1962). This method estimates TFP as a residual. This approach is capable of decomposing the contribution of factor inputs and technological change to output growth. The starting point of this approach is a standard Neo-classical production function of the form:

$$Y = F(K, L, A, t) \tag{1}$$

Where Y represents value added in agriculture, K the capital input, L the labour input, A the area under cultivation and, 't' stands for the time.

Differentiating equation (1) with respect to time, dividing it by Y, and rearranging it we get:

$$\frac{dY/dt}{Y} = \frac{\partial F/\partial K}{Y} K \cdot \frac{dK/dt}{K} + \frac{\partial F/\partial L}{Y} L \cdot \frac{dL/dt}{L} + \frac{\partial F/\partial A}{Y} A \cdot \frac{dA/dt}{A} + \frac{\partial F/\partial t}{Y} \tag{2}$$

In equation (2) the term $\frac{\partial F/\partial t}{Y}$ represents the proportional rate of shift of the production function. It is also known as technical change or TFP. The terms $\frac{\partial F/\partial L}{Y} L$, $\frac{\partial F/\partial K}{Y} K$ and $\frac{\partial F/\partial A}{Y} A$ are the factor shares of labour, capital, and area, respectively. If we denote growth rates of output, capital, labour and area inputs by small letters like y, k, l and a, and the shares of K, L, and A by S_K, S_L, and S_A respectively, then, equation (2) can be written as:

$$y = S_K k + S_L l + S_A A + TFPG \tag{3}$$

Where *TFPG* is growth rate of *TFP*. Equation (3) can be solved for *TFPG* as:

$$TFPG = y - S_K k - S_L l - S_A A \tag{4}$$

Using the data for growth rates of Y, K, L and A, and for factor shares of K, L and A equation (4) can be used to calculate *TFPG*. The contribution of K, L and A can also be found by multiplying their growth rates by their respective factor shares.

In the calculation of *TFP* it is generally assumed that production function is a well-behaved Neo-classical production function that allows the decomposition of sources of growth. Perfect competition, profit maximization and constant returns to scale are the other usual assumptions of growth accounting approach.

Under the above assumptions, equation (4) can alternatively be written as:

$$TFPG = y - \alpha k - \beta l - (1 - \alpha - \beta) A \tag{5}$$

Equation (5) calculates *TFPG* as a residual. It proxies as a "catch-all" variable and represents that part of output growth which cannot be explained by the growth of factor inputs. It is, therefore, a measure of our ignorance (Chen, 1997). It also measures the shift in the production function. The shift of the production function may be caused by a number of factors such as: "technical innovation, organizational and institutional change, shifts in the societal attitude, fluctuations in demand, changes in factor shares, omitted variables and measurement errors" (Basudeb and Bari, 2000:7).

DATA SOURCES

For the estimation of TFP growth in the agriculture sector of Pakistan, time series data about value added, area, labour and capital inputs are required. The sample period for this study is from 1965-66 to 2004-05. The data about capital stock is not available in national income accounts. Therefore, it has been estimated from gross fixed capital formation (GFCF) using perpetual inventory method.[5] The data about value added, cultivation Area, labour force and GFCF for agriculture sector, for the years from 1963-64 to 1995-96 were taken from *50 Years of Pakistan in Statistics*, Volume I, Summary, Federal Bureau of Statistics (FBS), Statistics Division, Government of Pakistan (GOP), Islamabad. The required data for the remaining period were taken from Pakistan Statistical Year Book 2006, FBS, Statistics Division, GOP, Islamabad. The value added and capital stock, are measured in millions of Rupees at constant factor costs of 1980-81.[6] The labour input is measured in millions of hours worked. Finally, the area input is measured in millions of acres.

IV. MEASUREMENT OF VARIABLES

Traditionally, the capital input is measured in net terms, *i.e.* net of depreciation. The crude measure of TFP includes the effect of technical efficiency as well as the effect of improved (intensive) use of inputs. In order to avoid the errors of measurement in TFP estimates we have adjusted the

[5]The estimation of capital stock is described in the Appendix.

[6]The year 1980-81 is a normal year and has been used as a base in national income accounts of Pakistan. Further, this year lies almost in the middle of our sample period. These are very reasons that we have used this year as a base for converting data series to a common base.

capital stock for variation in its utilization. One way of adjusting the TFP estimates for business fluctuations is the *Wharton Method*.[7] In this method, potential output is estimated by fitting a linear trend to capital output ratio (K/Y) and then the ratio of actual output to potential output is used as capacity utilization rate for adjusting the capital stock.[8]

Traditional estimates of TFP use the labour input as number of workers employed in the production. However, over time the average hours worked may change as a result of business fluctuations and/or as a result of changes in the behaviour of workers regarding their choice between leisure and work hours. Besides, the level of education and training acquired by the workers also improves over time. If TFP figures are estimated without making allowance for variations in the hours worked and improvement in the quality of labour as a result of education and training, the TFP estimates are likely to be overstated. In order to avoid the possible bias in the TFP estimates we have measured the labour input in terms of hours worked using data from various issues of *Labour Force Survey*. Further, we have adjusted the labour input for average schooling years (including the university education). The details of adjustment of the labour input for variations in the hours worked and for average schooling years[9] are given in the Appendix.

V. INTERPRETATION OF RESULTS

Table 3 contains the growth rates of value added in agriculture, inputs and TFP for the period 1965 to 2005. Following equation was used to calculate TFP estimates for the agriculture sector of Pakistan.

$$TFPG_t = \hat{V}_t - 0.37\hat{K}_t - 0.27\hat{L}_t - 0.36A\hat{r}ea_t \tag{6}$$

Where $TFPG_t$ = Growth rate of *TFP* in the agriculture sector

$\hat{V}_t$ = Growth rate of value added in the agriculture sector

$\hat{K}_t$ = Growth rate of capital stock adjusted for business fluctuations

[7]The other methods are *the Production Function method*, *Proxies for capacity utilization rate*, and *short-run adjustment*. The details of these methods are given in Oguchi (2004).

[8]The details of this procedure are given in the Appendix.

[9]The data regarding hours worked and education levels were not available for some years because *Labour Force Survey* was not conducted in those years. The missing values were generated through interpolation and extrapolation.

$\hat{L}_t$ = Growth of labour force adjusted for education and work hours

$A\hat{r}ea_t$ = Growth rate of area under all crops

The weights were obtained from the GLS[10] estimation of the Cobb-Douglas[11] production function under the assumption of constant returns to scale.

The average growth rate of value added in the agriculture sector over the sample period remained at 3.78 percent, however, growth performance widely fluctuated — ranging from the highest of 6.36 percent during the second half of the 1960s to the lowest of 1.98 percent during the recent half decade of 2001-05. The capital stock in the agriculture sector grew at an average rate of 1.95 percent during the sample period. Its highest growth rate stood at 3.69 percent during the 1980s whereas its lowest growth rate remained at 1.2 percent during the recent half decade 2001-05. Employed labour force in the agriculture sector showed an average growth rate of 1.03 percent over the sample period. Its minimum growth of 0.98 percent was observed during the 1970s. It recorded the highest growth rate of 1.22 percent during the 1990s. The area under all crops grew at an average rate of 0.52 percent over the sample period. Its growth fluctuated from the highest rate of 1.92 percent during the last half of the 1960s to the lowest of minus 0.06 percent during the recent half decade 2001-05. The TFP grew at an average rate of 0.28 percent. It started from a reasonably high growth rate of 1.6 percent during the later half of the 1960s. Its growth fell to minus 0.31 percent during the 1970s. It further deteriorated to minus 0.88 percent during the 1980s. It recovered and grew to 1.61 percent during the 1990s. During the recent half decade 2001-05 it again showed a negative growth rate of 0.23 percent. The higher TFP growth figures, in the agriculture, during the 1960s may be attributed to green revolution technology. In the 1970s, the depressive performance of TFP growth was the result of floods, viral

[10]Autocorrelation in the error term was found through LM procedure. The coefficient of autocorrelation was estimated through grid search procedure. The estimated value of autocorrelation coefficient was 0.62. This value was used to transform the variables and then GLS was applied.

[11]The shares of labour and capital in output can be estimated using wage rate and interest rates data which are not commonly available in developing countries like Pakistan. The alternative method is to estimate the shares of labour and capital by estimating the Cobb-Douglas form of production function, under the assumption of constant returns to scale, by an appropriate econometric technique.

diseases, and shortage of critical imported agriculture inputs because of very high petroleum prices. In the 1980s government liberalized sugar, pesticides and fertilizer industries. Monopoly power of Rice and Cotton Exports Corporation was abolished. The prices of outputs were raised. But the prices of inputs were also brought to the international standards. The bank credit increased for agriculture sector. A new high-yielding variety of cotton was developed. In spite of these policies TFP failed to recover and it remained negative. In the 1990s the government tried to bring input and output prices closer to international levels. It reduced subsidies and enhanced the role of private sector. As a result TFP growth improved to 1.61 percent in the 1990s. During first two years of the recent half decade a crippling drought touched the country and as a result agriculture growth turned to negative. In the following years due to increased availability of water TFP growth improved a little. During this half decade the use of all inputs also fell. All these factors led to negative growth of TFP in this period.

TABLE 3

Trends in Agriculture Value Added, Inputs and TFP Growth Rates (Percent)

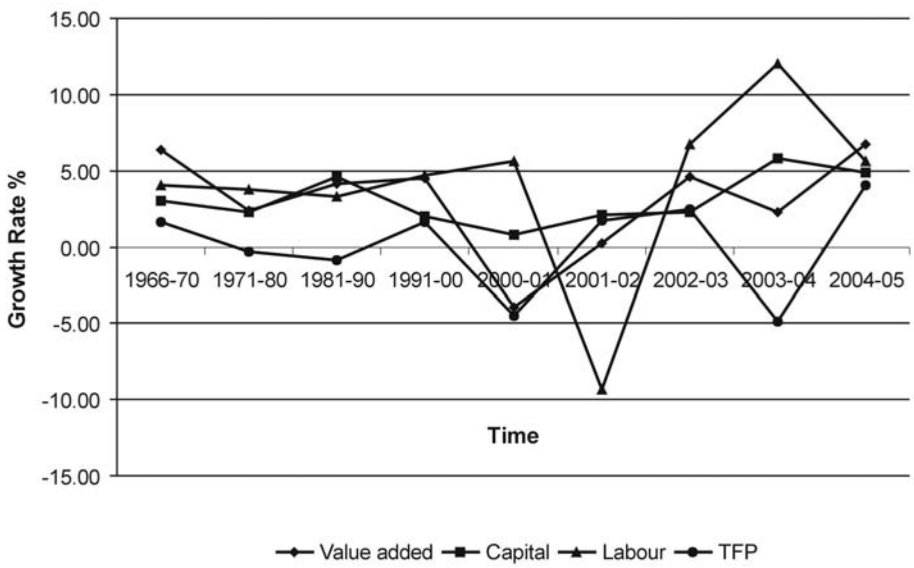
Source of Growth	1965-66 to 1969-70	1970-71 to 1979-80	1980-81 to 1989-90	1990-91 to 1999-2000	2000-01 to 2004-05	1965-66 to 2004-05
Value added	6.36	2.32	4.10	4.54	1.98	3.78
Capital	1.78	1.13	3.69	1.50	1.20	1.95
Labour	1.06	0.98	0.86	1.22	1.08	1.03
Cropped Area	1.92	0.51	0.43	0.22	-0.06	0.52
TFP	1.60	–0.31	–0.88	1.61	-0.23	0.28
Contribution to Value Added Growth by:						
Capital	27.97	48.70	90.14	32.96	60.48	51.53
Labour	16.67	42.35	20.90	26.94	54.31	27.22
Cropped Area	30.17	22.10	10.56	4.74	–3.13	13.74
TFP	25.19	–13.15	–21.59	35.35	–11.66	07.40

Source: Authors' estimates based on data taken from *50 Years of Pakistan in Statistics* and *Statistical Yearbook 2006*, FBS, GOP, Pakistan.

Figure 1 reveals that value added growth is more sensitive to growth rates of capital stock and cropped area but less sensitive to labour input growth. TFP growth is pro-cyclical, *i.e.* rising during expansion and falling during recessions. Capital growth is also closely associated with value added growth. The growth of labour force and cropped area are poorly associated with growth of value added.

FIGURE 1

Value Added (Adjusted) Inputs and TFP Growth (Solow Residual)



Source: Author's estimates based on data taken from *50 Years of Pakistan in Statistics* and *Statistical Year Book 2006*, FBS, Government of Pakistan.

The average contribution of capital stock to value added growth over the sample period remained at 51.53 percent. The next highest contribution to growth of value added was 27 percent by the labour force. The average contributions of cropped area and TFP were only 14 percent and 7 percent, respectively. It means that main contributors to growth of value added are the capital and labour inputs. The contribution of cropped area is only about 14 percent. The contributions of inputs and TFP to agriculture value added growth widely fluctuated over the sample period. Capital growth made highest contribution during the 1980s and the lowest contribution during the later half of the 1960s. The contribution of labour force to value added growth remained highest during the recent half decade of 2001-05 and it remained the lowest during the later half of the 1960s. Cropped area's maximum contribution was during the later half of the 1960s. During the recent period of 2001-05, its contribution was minus 3.13 percent. The TFP made highest contribution of 35.35 percent during the 1990s and the lowest contribution of about minus 22 percent during the 1980s.

VI. CONCLUSION AND POLICY IMPLICATIONS

Total factor productivity (TFP) has emerged as an important source of growth. But unfortunately in Pakistan TFP could not attract due attention of the researchers and policy makers. There are very few studies which have focussed on the estimation of TFP in the agriculture sector of Pakistan. However, these studies have produced overstated figures for agriculture TFP in Pakistan by ignoring the variation in the utilization of productive capacity, on one hand, and variation in the hours worked and improvement in the skills of workers resulting from increased level of education and training, on the other.

The present study has overcome this limitation by properly adjusting the capital and labour inputs for variation in capacity utilization and by incorporating the changes in wok hours and improvement in skills of labour force as a result of increased education and training.

The average growth rate of TFP in the agriculture sector of Pakistan remained at 0.28 percent. In Pakistan, we face limitations on the expansion of capital stock and cultivated area. The only available way of increasing agriculture value added is through increased TFP growth. However, unluckily this area could not catch the attention of authorities. It is strongly recommended that Federal Bureau of Statistics should estimate TFP on yearly basis and these estimates should be published along with other economic data. The government should also devise appropriate policies, such as diffusion of relevant information among the farmers, increased area under cultivation and timely availability of fertilizer at affordable prices for the farmer, to promote growth of agriculture TFP in the country.

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APPENDIX

ESTIMATION OF CAPITAL STOCK

The capital stock has been estimated using the perpetual inventory method which argues that the present stock of capital is the accumulation of past streams of investment.

$$K_t = w_t I_t + w_{t-1} I_{t-1} + \ldots + w_{t-T} I_{t-T} \quad \text{(A-1)}$$

Where $w_t = 1$, $0 < w_{t-I} < 1$ and I_{t-T} is the oldest surviving capital asset.

Assuming the geometric decay of capital stock and denoting the rate of depreciation by ϕ equation (A-1) can be written as:

$$K_t = I_t + (1-\phi) I_{t-1} + (1-\phi)^2 I_{t-2} + \ldots + (1-\phi)^T I_{t-T} \quad \text{(A-2)}$$

Writing equation (A-2) for $t-1$ and multiplying on both sides by $(1-\phi)$ gives us:

$$(1-\phi) K_{t-1} = (1-\phi) I_{t-1} + (1-\phi)^2 I_{t-2} + (1-\phi)^3 I_{t-3} + \ldots + (1-\phi)^{T+1} I_{t-(T+1)} \quad \text{(A-3)}$$

Subtracting equation (A-3) from (A-2), we get:

$$K_t - (1-\phi) K_{t-1} = I_t \quad \text{(A-4)}$$

The term involving $I_{t-(T+1)}$ drops out because any capital asset older than T periods no more exists. Equation (A-4) can be alternatively written as:

$$K_t = (1-\phi) K_{t-1} + I_t \quad \text{(A-5)}$$

From equation (A-5), we can deduce step-by-step that:

$$K_1 = (1-\phi) K_0 + I_1$$

$$K_2 = (1-\phi) K_1 + I_2 = (1-\phi) [(1-\phi) K_0 + I_1] + I_2 = (1-\phi)^2 K_0 + (1-\phi) I_1 + I_2$$

$$K_3 = (1-\phi) K_2 + I_3 = (1-\phi) [(1-\phi)^2 K_0 + (1-\phi) I_1 + I_2] + I_3 = (1-\phi)^3 K_0 + (1-\phi)^2 I_1 + (1-\phi) I_2 + I_3 \ldots\ldots\ldots$$

and for any period t as:

$$K_t = (1-\phi)^t K_0 + (1-\phi)^{t-1} I_{t-(t-1)} + (1-\phi)^{t-2} I_{t-(t-2)} + (1-\phi)^{t-3} I_{t-(t-3)} + \ldots + (1-\phi)^1 I_{t-1} + (1-\phi)^0 I_{t-0} \quad \text{(A-6)}$$

Using summation notation equation (A-6) can be written as:

$$K_t = (1-\phi)^t K_0 + \sum_{i=0}^{t-1} (1-\phi)^i I_{t-i} \quad \text{(A-7)}$$

Two issues are involved in the estimation of capital stock using equation (A-7). These are the estimation of initial capital stock, K_0 and determination of rate of depreciation, ϕ.

Initial capital stock K_0 can be estimated in a number of ways. One way, as used by Nehru and Dhareshwar (1993), is to estimate the initial investment by running a linear regression of log of investment against the time trend. The estimated value of initial investment is then used to estimate the initial capital stock using equation (A-8) as:

$$K_{t-1} = I_t / (\phi + g) \tag{A-8}$$

Where g is the rate of growth of output and ϕ is the rate of depreciation.

The second issue involved in the estimation of capital stock is to decide about the rate of depreciation. Ideally, the best way to estimate rate of depreciation of capital stock is to conduct a survey and then use the survey data to estimate the required rate of depreciation. But due to dearth of time and high cost involved, that is not feasible. The alternative way is to use estimates of other studies. Following Nehru and Dhareshwar (1993) and Kemal *et al.* (2002) we have assumed the rate of depreciation to be 4 percent.

Adjustment of the Capital Stock for Business Fluctuations

We have used the Wharton Method[12] to adjust the capital stock for business fluctuations. The steps involved in this method are as follows:

(*a*) Generate a capital/output (K/Y) series from capital and output data to be used for the analysis.

(*b*) Run a linear regression of this (K/Y) series against time and generate the estimated (K/Y) series.

(*c*) Plot the actual and fitted (K/Y) series against time.

(*d*) Draw a line parallel to the (K/Y) trend line passing through the minimum points of the actual (K/Y) series.

(*e*) The capacity or potential capital/output (K^*/Y^*) ratio will lie on the lower line.

(*f*) Potential output is measured using the equation: $Y^* = K / (K^* / Y^*)$.

(*g*) Take the ratio of actual to potential output, (Y/Y^*) as the capacity utilization ratio.

[12]For details of this method see Oguchi, (2004).

(*h*) The product of K and (Y/Y^*) is the adjusted capital stock series.

Adjustment of Labour Input for Work Hours and Education

The *Labour Force Survey* published by FBS, Government of Pakistan, contains details of hours worked by labour force employed in various economic activities like GDP, Agriculture, Manufacturing, and Services sectors etc. In each activity, the number of hours worked in each class, are multiplied by the fraction of labour force lying in that class. The sum of these products is the weighted average of hours worked in a particular activity.

The *Labour Force Survey* also gives the details of education levels acquired by various fractions of employed labour force. The weighted average of various education levels in an economic activity was taken as the average school years. The fraction of employed labour force acquiring a particular level of education was used as a weight. The average education level series were then used to adjust the labour force for variation in education levels using the following equation:

$$L_{t,ce} = Lt\,(1 + \lambda e) \qquad \text{(A-9)}$$

Where

$L_{t,ec}$ = Total labour force employed in an activity adjusted for education level.

Lt = Total number of workers employed in an activity.

λ = The literate fraction of employed labour force in an activity.

e = Average education level of the employed labour force in an activity.

Then multiplying the constant-education labour force with the average hours worked gave us the total labour input adjusted for variations in hours worked and in education level.