Health Status, Labour Productivity And Economic Growth : A Production Function Approach

**** Harinder Singh Gill***

INTRODUCTION

Healthier workers are physically and mentally more energetic and robust. They are more productive and thus, earn higher wages. They are also less likely to be absent from work because of illness (or illness in their family). Illness and disability are more pronounced factors in reducing wages substantially, especially in developing countries, where a higher proportion of the work force is engaged in manual labour (Strauss & Thomas,1998). Health in the form of life expectancy, has appeared in many cross countries' growth regression, and investigators generally find that it has a significant positive effect on the growth that includes health as a determinant of economic growth (Bloom & Canning; 2000, 2003). Higher life expectancy is generally associated with better health status and lower morbidity (Murray & Chen, 1992; Murray & Lopez, 1997).

The present study is to include health in a well-specified aggregate production function in an attempt to test for the existence of effect of health on labour productivity. A human capital is multidimensional, so a model of growth will include all its major components. Thus, this paper aims to determine the effect of physical capital, labour and human capital consisting of three dimensions - education, experience and health on economic growth. To achieve this objective, the aggregate production function that expresses a country's output as a function of its inputs and the efficiency with which it uses these inputs has been used. These inputs are physical capital, labour and human capital in the three dimensions of education, experience and health. Following Bloom, David and Sevilla (2004), only those indicators are included, which represent health status in an aggregate production function. This has been done to test the existence or otherwise of an effect of health on labour productivity, and to measure its strength. All the parameters of this production function have been estimated using panel data for 2000 and 2010 to obtain measures of the relative contribution of each of the inputs to economic growth.

PRODUCTION FUNCTION

Economic growth can be decomposed into two sources: growth at the level of inputs, and growth in the Total Factor Productivity (TFP). Physical capital, labour and human capital are the inputs. The following Aggregate Production Function is used to express the relationship between output and inputs and technology.

$$Y = A\,K^{\alpha}\,L^{\beta}\,e^{\phi_1 s + \phi_2 \exp + \phi_3 \exp^2 + \phi_4 hu + u} \qquad \text{------(1)}$$

where

- Y: is output or Gross Domestic Product (GDP);
- A: is TFP;
- K: is physical capital;
- L: is the labour force;
- s: is the average years of schooling;
- exp: is the average work experience of the work force;
- exp^2: is the square of an average work experience;
- h: is health (which is proxyed by life expectancy at birth);
- u: stochastic term.

The effect of the human capital is expressed as powers of an exponential. The advantage of this functional form is that it shows the impact of the level of schooling, experience, experience squared and health status on labour productivity, which is compatible with the relationship usually estimated in microeconomic studies (Klenow & Rodriguez-Clare,1997; Prescott, 1998; Young,1994 & 1995; Mincer, 1974).

* *Associate Professor and Head,* Department of Management Studies And Computer Applications, Amritsar College of Engineering And Technology, Amritsar, Punjab. E-mail: harindersinghmajitha@yahoo.co.in

For simplicity, it is assumed that the effect of health and schooling on output depends only on the average level of health and schooling in the economy and not on its distribution.

By taking logarithms of the aggregate production function, the following production function has been estimated by two square least square (2SLS) techniques.

$$y_{it} = a_{it} + \alpha k_{it} + \beta l_{it} + \phi_1 s_{it} + \phi_2 \exp_{it} + \phi_3 \exp^2_{it} + \phi_4 h_{it} + u_{it} \quad \text{------(2)}$$

where y_{it}, k_{it}, and l_{it} are the logarithms of output or gross domestic product (GDP) (Y_{it}), physical capital (K_{it}) and labour force (L_{it}) in country *i* at time *t* respectively. The level of TFP in country *i* at time *t*, is not observed and appears as an error term when the equation is estimated.

In order to find out the factors which are responsible for inter country variations in labour productivity, Karl Pearson Coefficient of Correlation for the selected variables have been computed by using the following formula:

$$r_{ij} = \frac{Cov(x_i, x_j)}{\sigma_{xi}\, \sigma_{xj}} \quad \text{------(3)}$$

where $\text{Cov}(x_i, x_j)$ is covariance between variable x_i and x_j. The symbols σ_{xi} and σ_{xj} denotes the standard deviations of variable x_i and x_j respectively.

Correlation coefficient helps in identifying the most important factors in explaining inter-country variations. It also helps in knowing how the relative importance of different variables changes over time. To test the significance of correlation coefficients, t-test has been applied.

$$t = \frac{r_{ij}}{\sqrt{1 - r_{ij}^2}} \sqrt{n-2} \quad \text{------(4)}$$

where *n* is the number of pairs of observations (countries) and r_{ij} is the correlation coefficient between i^{th} and j^{th} variable.

SOURCES OF DATA

Panel data for different countries has been constructed at two points of time i.e. in the year 2000 and 2010.

1. Data of Output or Gross Capital Formation (in percentage of GDP), Labour force (in million) and Life Expectancy at Birth (in years) were obtained from various issues of world development indicators;

2. Average total years of schooling of the population aged 15 and older were taken from Barro and Lee data set (2010);

3. Experience is simply the amount of time spent in labor force. It has been worked out as average age minus average years of schooling minus the age at which schooling starts, which is uniformly assumed to be six years (Barro and Lee, 2010).

Analysis has been carried out separately for developing countries and all countries. Countries were categorized as developing countries on the basis of World Bank's grouping of countries.

CORRELATION BETWEEN VARIABLES: 2000

The coefficient of correlation between variables in the year 2000, for all and developing countries were calculated in order to find out the problem of multicolinearity and the results are presented in the Table 1. The lower diagonal of the Table 1 shows the correlation between variables of developing countries and upper diagonal of all countries. It is clear from the table that log of output, life expectancy at birth, and average years of schooling are all positively correlated in all as well as developing countries. Log of output and life expectancy at birth are negatively correlated with average experience and average experience square in all and developing countries. Average experience, average experience square, and log of labour force are negatively correlated with log of output in all and developing countries for the year 2000.

The average years of schooling, experience and experience square are highly correlated. This high degree of correlation makes it difficult to disentangle the effect of each input. So, results were carried out by considering these variables independently.

Table 1 : Correlation Matrix of All And Developing Countries (**): 2000							
	Log output	**Log labour force**	**Log capital**	**Life expectancy at birth**	**Average years of schooling**	**Experience**	**Experience square**
Log output		-0.078	0.219	**0.754***	**0.708***	**-0.708***	**-0.711***
Log labour force	-0.153		0.045	0.070	-0.004	0.005	-0.023
Log capital	0.202	0.033		**-0.322***	**0.307***	**-0.305***	**-0.268***
Life expectancy at birth	**0.686***	0.052	**0.309***		**0.793***	**-.794***	**-0.799***
Average years of schooling	**0.624***	-0.009	**0.308***	**0.763***		**-0.999***	**-0.997***
Experience	**-0.623***	0.011	**-0.307***	**-0.763***	**-0.999***		**-.977**
Experience square	**-0.623***	-0.021	**-0.258***	**-0.766***	**-0.968***	**0.968***	

* indicates significant at five percent level of significance.

(**) The lower diagonal of the table shows the correlation between variables of developing countries and upper diagonal of all countries.

RESULTS AND DISCUSSION: 2000

The relationship of gross domestic product with physical capital, labour, average years of schooling and life expectancy at birth act as explanatory variables which were estimated for all countries for the year 2000. The analysis has been carried out for 66 counties for which the data were available. Results (Table 2, Eq. I) show that 64.2 percent variation in the gross domestic product per workers is explained by these explanatory variables taken together. Coefficients of life expectancy at birth and average years of schooling have a positive relation and physical capital, and labour have a negative relation with economic growth, but their effects are non-significant. The study found that not even a single explanatory variable had a significant effect on economic growth in combination of the variables. Effort has also been made to find out the relationship by introducing one more explanatory variables - experience and excluding average years of schooling from the model because of high degree of collinearity between average years of schooling, experience and experience square and the results are presented in the Table 2. Table 2 (Eq. II) shows that 75.2 percent variations in the dependent variable are explained by these explanatory variables. Coefficient of life expectancy at birth and experience turn out to remain significant. Coefficient of labour is negative and is significant at ten percent level of significance (-0.12). Coefficient of physical capital has a negative relation with economic growth, but its effect turns out to be non-significant.

When experienced square is introduced in the model, the value of R^2 marginally falls to 74.3. However, only the effect of life expectancy at birth remains significant and that of experience turns out to be insignificant. Coefficients of physical capital and experience square has a positive, whereas labour and experience have a negative relation with economic growth, but their effects turn out to be non-significant. The value of R^2 increases from 64.2 percent (Eq. I) to 75.2 percent (Eq. II) due to the introduction of experience, but exclusion of average years of schooling. Thus, the study highlights that life expectancy at birth affects economic growth positively and significantly.

Effort has also been made to work out the relationship of developing countries (excluding high income countries) with the same set of explanatory variables. The analysis has been carried out for 54 developing counties for which the data were available and the results (Table 2, Eq. IV) show that 58.8 percent variation in the dependant variable are explained by the same set of explanatory variables. Coefficients of life expectancy at birth and average years of schooling have a positive and physical capital and labour have a negative relation with economic growth, but their effects are non-significant. Effort has also been made to work out the relationship by including experience and excluding average years of schooling because of high collinearity between average years of schooling, experience and experience square and the study found that 68.7 percent variation in the dependent variable are explained by explanatory variables.

Coefficient of life expectancy at birth, labour and experience turns out to be significant when average years of schooling is explained from the model. Coefficients of labour and experience are negative and significant and that of capital also has a negative relation with economic growth, but its effect is non-significant. When experienced square is introduced in the model, the value of R^2 remains the same. However, the effect of life expectancy at birth and labour

Table 2 : Production Function With Growth Rate of GDP As The Dependent Variable : 2000						
	Non- Linear Two Stage Least Square Estimates of All Countries			Non-Linear Two Stage Least Square Estimates of Developing Countries		
	Eq. I	Eq. II	Eq. III	Eq. IV	Eq. V	Eq. VI
Capital	-0.81 (-0.54)	-0.04 (-0.06)	0.35 (0.39)	-0.72 (-0.48)	-0.26 (-0.37)	0.35 (0.47)
Labour	-0.03 (-0.20)	-0.12 (-1.69)**	-0.12 (-1.64)	-0.07 (-0.57)	-0.12 (-1.76)**	-0.12 (-1.75)**
Average years of schooling	0.64 (1.12)			0.59 (1.60)		
Experience		-0.24 (-2.95)*	-1.11 (-0.55)		-0.23 (-2.69)*	-0.66 (-0.29)
Experience^2			0.02 (0.43)			0.007 (0.19)
Life expectancy at Birth	0.01 (1.15)	0.07 (3.40)*	0.07 (2.67)*	0.01 (0.17)	0.05 (2.54)*	0.05 (2.11)*
Constant	8.35 (1.03)	10.87 (2.61)	20.99 (0.86)	8.25 (1.02)	11.13 (2.56)	16.50 (0.56)
DF	61	61	60	49	49	48
R^2	0.642	0.752	0.743	0.588	0.687	0.687

Note: 1. Capital and labour are non-linear; schooling, experience, experience square and life expectancy are linear.
2. Values within parentheses are t-values.
3. * and ** indicates significance at five and ten percent level of significance respectively.

remains significant and that of experience turns out to be non significant. The value of R^2 increases from 58.8 (Eq. IV) percent to 68.7 (Eq. VI) percent due to the introduction of experience as another explanatory variable and excluding average years of schooling.

The empirical analysis shows that improved health as proxied by life expectancy at birth has a positive impact on economic growth by introducing the labour productivity in all and developing countries. Coefficient of labour force, which was non-significant in all countries, turns out to be significant in case of developing countries. Coefficient of capital continues to be non-significant in both the cases. The analysis shows that improved health positively impacts labour productivity and economic growth in all and developing countries.

CORRELATION BETWEEN VARIABLES: 2010

The correlation between variables for the year 2010 for all and developing countries were calculated in order to find out the problem of multicollinearity and the results are presented in the Table 3. The lower diagonal of the Table 3 shows the correlation between variables of developing countries and upper diagonal of all countries. It is clear from the Table 3 that log of output, life expectancy at birth and average years of schooling are all positively correlated in all as well as developing countries. Log of output and life expectancy at birth are negatively correlated with average

Table 3 : Correlation Matrix of All and Developing Countries (**) : 2010							
	Log output per worker	Log labour force	Log capital per worker	Life expectancy at birth	Average years of schooling	Experience	Experience square
Log output per worker	1.00	-0.144	**0.265***	**0.741***	**0.695***	**-0.695***	**-0.572***
Log labour force	-0.224	1.00	-0.004	0.157	0.034	-0.034	-0.028
Log capital per worker	**0.256***	0.024	1.00	0.255	0.171	-0.171	-0.162
Life expectancy at birth	**0.638***	0.181	**0.239***	1.00	**-0.723***	**-0.723***	**-0.711***
Average years of schooling	**0.517***	0.006	0.185	**0.658***	1.00	**-0.999***	**-0.989***
Experience	**-0.517***	-0.006	-0.185	**-0.658***	**-0.999***	1.00	**0.989***
Experience square	**-0.526***	-0.016	-0.184	**-0.669***	**-0.999***	**0.999***	1.00

* indicates significant at five percent level of significance. **(**)** The lower diagonal of the table shows the correlation between variables of developing countries and upper diagonal of all countries.

experience and average experience square in all and developing countries. Average experience, average experience square and log of labour force are negatively correlated with log of output per worker in all and developing countries for the year 2010.

The average years of schooling, experience and experience square are highly correlated. This high degree of correlation makes it difficult to disentangle the effect of each input. So, the results were carried out by considering these variables independently.

RESULT AND DISCUSSION: 2010

The relationship of gross domestic product with physical capital, labour, average years of schooling and life expectancy at birth as explanatory variables have been estimated for all countries for the year 2010. The analysis has been carried out for 60 counties for which the data were available. Results (Table 4, Eq. I) show that 67.9 percent variations in gross domestic product are explained by physical capital, labour, average years of schooling and life expectancy at birth taken together. Coefficient of life expectancy at birth (0.08) is positive and that of labour (-0.31) is negative, and both are significant at the five-percent level of significance. Coefficient of average years of schooling is positive and significant, whereas, capital is positive and non significant at the five-percent level of significance respectively. Effort has also been made to find the relationship by introducing experience and excluding average years of schooling from the model because of high degree of collinearity between the average years of schooling, experience and experience square and the results are presented in the Table 4, Eq. II. The Table 4 shows that 67.9 percent variations in the dependent variable are explained by these explanatory variables. Coefficient of life expectancy at birth and labour remains significant as in equation Table 4, Eq. III.

When experienced square is introduced in the model, the value of R^2 decreases marginally to 66.2 percent (Eq.III). However, the effect of life expectancy at birth and labour remains significant and that of physical capital, experience and experience square remains non-significant. Thus, the study highlights that again, life expectancy at birth and education affects the labour productivity positively and significantly.

Effort has been made to work out the relationship of developing countries (excluding high-income countries with the same set of explanatory variables. The results show that 55.3 percent variations in the dependent variables are explained explanatory variables. Coefficients of life expectancy at birth and labour remain significant as in previous equations and that of physical capital and average years of schooling have a non-significant effect on labour productivity and economic growth. Effort has also been made to work out the relationship by including experience and excluding average years of schooling. The result shows that 55.2 percent variations in the dependent variable are explained by these explanatory variables. Coefficient of life expectancy at birth and labour remains significant as in

Table 4 : Production Function with Growth Rate of GDP As The Dependent Variable : 2010

	Non- Linear Two Stage Least Square Estimates of All Countries			Non-Linear Two Stage Least Square Estimates of Developing Countries		
	Eq. I	Eq. II	Eq. III	Eq. IV	Eq. V	Eq. VI
Capital	1.21 (1.38)	1.22 (1.39)	1.08 (1.11)	1.29 (1.45)	1.29 (1.45)	1.28 (1.44)
Labour	-0.31 (-3.47)*	-0.32 (-3.47)*	-0.32 (-3.42)*	-0.33 (-3.54)*	-0.33 (-3.54)*	-0.33 (-3.54)*
Average years of schooling	0.22 (2.30)*			0.12 (0.93)		
Experience		-0.22 (-2.28)*	-1.37 (-1.10)		-0.12 (-0.93)	0.74 (0.44)
Experience^2			0.02 (0.91)			-0.01 (-0.51)
Life expectancy at birth	0.08 (3.11)*	0.08 (3.10)*	0.08 (3.00)*	0.07 (2.72)*	0.07 (2.72)*	0.07 (2.42)*
Constant	-0.70 (-0.31)	6.95 (1.68)	22.69 (1.29)	-0.39 (-0.17)	3.61 (0.72)	8.29 (-0.35)
DF	65	65	64	54	54	53
R^2	0.679	0.679	0.662	0.553	0.552	0.557

Note: 1. Capital and labour are non-linear; schooling, experience, experience square and life expectancy are linear.
2. Values within parentheses are t-values.
3. * and ** indicates significance at five percent and ten percent level respectively.

equation IV. Coefficient of other explanatory variables remains non-significant as shown in the equation III.
When experienced square is introduced in the model, the value of R^2 increases marginally to 55.7 percent (Eq. VI). However, the coefficient of experience square remains non-significant in all as well as developing countries. Thus, the study highlights that life expectancy at birth affects the labour productivity positively and significantly.
The effect of life expectancy at birth, average years of schooling and experience on labour productivity and economic growth continued to be significant, and the impact of capital and experience square continued to be non-significant in 2010 when all (including high-income countries and developing countries) countries were considered independently. The empirical examination showed that improved health as proxied by life expectancy at birth and average years of schooling have a positive impact in improving the labour productivity and thus, economic growth in countries at different points of time, that is, 2000 and 2010. The impact of life expectancy at birth, experience and labour continued to be significant and that of capital remained non-significant with the passage of time from 2000 to 2010. The impact of experience square was non-significant and that of average years of schooling was significant in 2000, as well as in 2010. The empirical examination shows that improved health and average years of schooling increases labour productivity, which in turn effects economic growth positively and significantly in developing countries.

CONCLUSION

Correlation between variables was worked out and the study showed that log of capital, life expectancy at birth and average years of schooling were positively correlated with log of output; however, log of labour force, experience and experience square were negatively correlated with log of output for the year 1980, 2000 and 2010 both in case of all the countries (including high-income countries and developing countries separately). Log of output, life expectancy at birth and average years of schooling were negatively correlated with average experience, and average experience squared. Average experience and average experience square were highly positively correlated, making it difficult to disentangle their effects in aggregate data. So, the results were carried out by considering these variables independently. The study found that life expectancy at birth as a proxy of health affected labour productivity and economic growth significantly, whereas, the effect of capital and experience square were found to be non-significant for the years 2000 and 2010 when all and developing countries (excluding high-income countries were considered separately. The effect of average year of schooling was found to be significant in 2010 in case of all countries. The value of R^2 increased from 61.7 percent in 2000 to 66.4 percent in 2010. The analysis showed that average years of schooling have a positive impact in improving the labour productivity and thus, the economic growth in countries in 2010. The impact of life expectancy at birth and experience continued to be significant and that of capital remained non-significant with the passage of time from 2000 to 2010. The impact of experience square was non-significant and that of average years of schooling was significant in 2000 as well as in 2010. The empirical examination shows that improved health and average years of schooling increases labour productivity, which in turn affects economic growth positively and significantly in developing countries.
Over a period of time from 2000 to 2010, impact of life expectancy at birth remained significant, but other explanatory variables continued to be non-significant. The value of R^2 decreased from 75.2 percent in 2000, to 55.7 percent in 2010, with a different set of explanatory variables.
Overall, the study has found that health and education have a positive and statistically significant effect on labour productivity and thus, on economic growth. One year improvement in a population's life expectancy contributes to an increase in 5 to 11 percent in gross domestic product. This is a relatively large effect, indicating that increased expenditure on improving health as well as education is justified purely on the ground of its impact on labour productivity, quite apart from the direct effect of improved health on gross domestic product.

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