African Journal of Business Management Vol. 6(1), pp. 280-285,11 January, 2012
Available online at http://www.academicjournals.org/AJBM
DOI: 10.5897/AJBM11.2104
ISSN 1993-8233 ©2012 Academic Journals

Full Length Research Paper

Impact of human capital on economic growth with emphasis on intermediary role of technology: Time series evidence from Pakistan

Muhammad Amir[1]*, Bilal Mehmood[2] and Muhammad Shahid[3]

[1]Department of Economics, Government Dyal Singh College, Lahore, Pakistan.
[2]Department of Economics, Government College University, Lahore, Pakistan.
[3]Department of Economics, University of the Punjab, Lahore, Pakistan.

Accepted 12 October, 2011

This study examines the impact of education sector of Pakistan on economic growth for the recent data. We have taken technology as dynamic variable, instead of taking it as exogenous to study the impact of human capital on economic growth through technology. So, impact of human capital is studied in detail with technology, both as exogenous and endogenously taken into account. Johansen co-integration test establishes a long run relationship between human capital and economic growth, followed by error correction model (ECM) for short run analysis.

Key words: Human capital, technology, economic growth.

INTRODUCTION

Human capital formation is the best indigenous choice available for economic growth. Two famous economists are cited regarding new growth theory. Lucas (1990) is of the view that human capital is the important determinant of economic growth whereas according to Romer (1990), economic growth depends upon research and development (R&D) and spillovers from R&D process. Romer does not negate the crucial significance of human capital. In both of the views, primary importance of human capital is not ruled out. In this study, we have analyzed the significance of human capital for Pakistan in Lucas and Romer's growth mechanisms.

Objective of the study

This article tries to explore the role of technology on the relationship between human capital and economic growth. We set the following statement for achieving this objective. Use of technology enhances the relationship between human capital and economic growth.

LITERATURE REVIEW

The debate on role of technology and human capital can be attributed to Nelson and Phelps (1966). They studied the relationship between structures of capital technological progress. According to their findings in countries which are technologically advanced, the returns to education are higher. Hence, a society should devote more resources for human capital formation as it facilitates in setting up more dynamic indigenous technology. So, technology diffusion can be accelerated by investing more in education. Lucas (1988) provided the basis for empirical research on human capital based endogenous growth models. According to him, investment in human capital and constant returns can be avoided. Uzawa (1965) considered human capital as a factor of production. Therefore, Uzawa and Lucas consider human capital is skill embodied-labor, and if labor uses its skills in one profession, it precludes the use in some other profession. Romer (1990) modeled long run economic

*Corresponding author. E-mail: amirmoaavia@gmail.com. Tel: +92-42-03214144574.

growth on research and development (R&D). So, according to Romer, when firms are involved in R&D, it results in technological change and enhances total factor productivity (TFP) which becomes the immediate cause of economic growth. Further, his study concluded that knowledge cannot be confined within geographical boundaries.

Mankiw et al. (1992) discussed the degree of variability in education in different countries. In their opinion, human capital augmented-neoclassical production function gives such coefficients of human capital that remain insignificant for labour abundant countries (if some exceptional observations are excluded).

Musibau and Rasak (2005) have studied long run relationship between education and economic growth in Nigeria. They have used two channels to test the significance of human capital for economic growth. In the first channel, human capital is used as an independent factor of production and in the second channel; human capital affects economic growth through technology parameter. According to their findings, a well educated labor force significantly affects economic growth through both channels.

Benhabib and Spiegel (1994) have deduced that international technology spillover rates depends upon the availability of human capital in follower country and this human capital is guaranteed through education.

Abbas and Foreman-Peck (2008) have identified the crucial role of human capital to absorb the world technological progress. They have concluded that nature of economic growth in Pakistan is of endogenous nature. Returns to secondary education are below the expected level which means there is a deficiency in investment in human capital formation. There is inconsistency in policies for human capital formation in Pakistan because population have increased so rapidly in the last decade but educated labor force has not increased at the same rate which reflects negative contribution towards economic growth.

THE MODEL

The model used in this study is borrowed from Romer (1990). According to Romer:

$Y_t = f(K_t, L_t, H_t)$

Its modified form in terms of Cobb-Douglas production function is given by:

$Y_t = A_t K_t^{\alpha} L_t^{\beta} H_t^{\gamma} e_t$

Y_t = GDP; K_t = gross domestic investment used as proxy variable for capital; L_t = employment level as proxy for labor; H_t= enrolment rates used as proxy variable for human capital.

Following Barro (1991), we have used gross investment rates as proxy for physical capital, so, in this study, we have used gross domestic investment rate as a proxy variable for physical capital. Regarding the proxy for measuring human capital, Romer (1990) used schooling enrollment rates by dividing number of skilled adults with total population of adults. These Schooling Enrollment Rates are obtained by the following formula:

$$SER = \frac{\text{Total enrollment in specific grade}}{\text{Total population of corresponding age group}}$$

In order to test the significance of human capital for economic growth, we have divided the research into two segments as discussed thus.

Empirical test 1: Human capital and economic growth

To study the impact of human capital on economic growth, a model based upon neoclassical production function is used:

$Y_t = f(K_t, L_t, H_t)$

Its equation form:

$$Y_t = A_t K_t^{\alpha}\ L_t^{\beta} H_t^{\gamma} e_t$$

For transforming this Cobb-Douglas production function into linear form, take log on both sides:

$$ln(Y_t) = ln\ (A_t K_t^{\alpha} L_t^{\beta} H_t^{\gamma} e_t)$$

Expanding logarithms:

$$\ln(Y_t) = \ln\{(A_t)\} + \alpha\{\ln(K_t)\} + \beta\{\ln(L_t)\} + \gamma\{\ln(H_t)\} + \ln(\varepsilon_t) \quad \text{i}$$

So, the following is the main equation of our study:

$$\ln(Y_t) = a_t + \alpha\{\ln(K_t)\} + \beta\{\ln(L_t)\} + \gamma\{\ln(H_t)\} + \Phi_t \quad \text{ii}$$

We shall use enrollment rates at different levels, to see the impact of human capital on economic growth. These proxy variables are:

Primary enrollment rate = H_p
Secondary enrollment rate = H_s
College enrollment rate = H_{col}
University enrollment rate = H_{uni}
Vocational enrollment rate = H_{voc}

By replacing these aforementioned enrollment rates into equation (ii), we shall get separate equation for each level of education:

$$\ln(Y_t) = a_t + \alpha\{\ln(K_t)\} + \beta\{\ln(L_t)\} + \gamma\{\ln(H_p)\} + \varepsilon_t \quad \text{iii}$$
$$\ln(Y_t) = a_t + \alpha\{\ln(K_t)\} + \beta\{\ln(L_t)\} + \gamma\{\ln(H_s)\} + \varepsilon_t \quad \text{iv}$$
$$\ln(Y_t) = a_t + \alpha\{\ln(K_t)\} + \beta\{\ln(L_t)\} + \gamma\{\ln(H_{col})\} + \varepsilon_t \quad \text{v}$$
$$\ln(Y_t) = a_t + \alpha\{\ln(K_t)\} + \beta\{\ln(L_t)\} + \gamma\{\ln(H_{uni})\} + \varepsilon_t \quad \text{vi}$$
$$\ln(Y_t) = a_t + \alpha\{\ln(K_t)\} + \beta\{\ln(L_t)\} + \gamma\{\ln(H_{voc})\} + \varepsilon_t \quad \text{vii}$$

Empirical test 2: Impact of human capital on economic growth through technology

To study the impact of human capital on economic growth through technology, we take level of technology as a function of two exogenous variables, ratio of total imports to gross fixed capital formation and expenditures on research and development (R&D). Technological development is the outcome of resources devoted to research and development. Discovery and innovations depends upon two factors; number of people involved in research and the stock of already done research work. The stock of research work

Table 1a. Estimated values of Augmented Dickey Fuller (ADF) test statistics.

Variable name	At level	At first difference
Yt	-0.31	-4.25
Kt	1.65	-8.28
Lt	-0.95	-6.14
ImpGcf	-2.40	-8.56
ExRnD	-0.08	-6.40
Hp	-0.53	-5.01
Hs	0.27	-5.38
Hh	-0.32	-5.81
Hu	-1.10	-6.21
Hvoc	0.36	-4.02

At 5% level of significance, critical value is -2.95.

enhances the productivity of new researchers. More expenditures on R&D; the more will be research work (Jones, 2002).

In developing countries like Pakistan, growth is driven by transfer of ideas and technology; so these economies grow when technology enters into their geographical boundaries through imported goods. Further, higher level of human capital will facilitate the adoption of foreign technology which will reduce the knowledge gap between developed and developing countries (Nelson and Phelps, 1966). Standard neo-classical production with human capital as distinct determinant:

$$Y_t = A_t K_t^{\alpha} L_t^{\beta} H_t^{\gamma} \varepsilon_t$$

In order to transform this Cobb-Douglas production function into linear form, we take log on both sides:

$$ln(Y_t) = ln(A_t K_t^{\alpha} L_t^{\beta} H_t^{\gamma} \varepsilon_t)$$

$ln(Y_t)= ln(A_t)+ \alpha\{ln(K_t)\}+ \beta\{ln(L_t)\}+ \gamma\{ln(H_t)\}+ ln(\varepsilon_t)$ viii

Technology parameter is assumed to be dynamic rather than exogenous to model:

$ln(A_t)= \lambda_o + \lambda_1\{ln(ImpGcF_t)\} + \lambda_2\{ln(ExRnD_t)\} + \varepsilon_{A,t}$ ix

By replacing the technology parameter into equation (viii), we get equation (x):

$ln(Y_t) = \lambda_o + \lambda_1\{ln(ImpGcF_t)\}+ \lambda_2\{ln(ExRnD_t)\} + \alpha\{ln(K_t)\}+ \beta\{ln(L_t)\}+\gamma\{ln(H_t)\}+ \acute{\varepsilon}_{A,t.}$ x

Where:

$$ImpGcF_t = \frac{\text{Total imports}}{\text{Gross domestic fixed capital formation}};$$

$ExRnD_t$ =expenditures on research and development.

ImpGcF is a ratio of two variables; imports and gross fixed capital formation. As imports enter into the geographical boundaries of a country, they become immediate cause of transfer of technology. As a country imports and at the same time starts producing the import substitutes through domestic investment and rate of growth in domestic investment is faster than growth of imports, then the whole fraction ImpGcF would diminish with respect to time. So, if ImpGcF establishes a negative relationship with GDP, it means technological development is taking place in recipient country. So, along with expenditures on research and development, second variable used for technology parameter is ImpGcF. As far as expenditures on research and development are concerned, the more we allocate for research and development, the more it adds to the existing stock of knowledge and make production functions more efficient. For five different levels of education:

$ln(Y_t) = \lambda_o + \lambda_1\{ln(ImpGcF_t)\}+ \lambda_2\{ln(ExRnD_t)\}+ \alpha\{ln(K_t)\}+\beta\{ln(L_t)\}+ \gamma\{ln(H_p)\} + \acute{\varepsilon}_{p,t}$ xi

$ln(Y_t)= \lambda_o + \lambda_1\{ln(ImpGcF_t)\}+ \lambda_2\{ln(ExRnD_t)\}+ \alpha\{ln(K_t)\}+ \beta\{ln(L_t)\}+ \gamma\{ln(H_s)\} +\acute{\varepsilon}_{s,t}$ xii

$ln(Y_t)= \lambda_o + \lambda_1\{ln(ImpGcF_t)\}+ \lambda_2\{ln(ExRnD_t)\}+ \alpha\{ln(K_t)\}+ \beta\{ln(L_t)\}+ \gamma\{ln(H_{col})\} + \acute{\varepsilon}_{col,t}$ xiii

$ln(Y_t)= \lambda_o+ \lambda_1\{ln(ImpGcF_t)\}+ \lambda_2\{ln(ExRnD_t)\}+ \alpha\{ln(K_t)\}+\beta\{ln(L_t)\}+\gamma\{ln(H_{uni})\} +\acute{\varepsilon}_{uni,t}$ xiv

$ln(Y_t)= \lambda_o + \lambda_1\{ln(ImpGcF_t)\}+ \lambda_2\{ln(ExRnD_t)\}+\alpha\{ln(K_t)\}+\beta\{ln(L_t)\} + \gamma\{ln(H_{voc})\} +\acute{\varepsilon}_{voc,t}$ xv

In order to test the long run relationship between two or more than two time series, co-integration technique is used. So, in this research, we use Johansen Co-integration test to investigate the long run relationship among dependent and independent variables.

EMPIRICAL FINDINGS

Most of the times, dealing with the time serial data, it often shows the property of non stationarity at level form. We have tested the stationarity of the data through unit root tests. In this regard, Augmented Dickey Fuller (ADF) and Phillips Perron (PP) test are used.

Unit root test results

In this research, we have used both Phillips Perron (PP) and Augmented Dickey Fuller (ADF) tests in order to test the stationarity of the data.

Augmented Dickey Fuller test statistics

The results of the Augmented Dickey Fuller (ADF) are presented in Table 1a. These results reveal that at level form, estimated values of t-statistics for all variables are not significantly negative. Therefore the data is not stationary at level form. The results of the differenced variables show that estimated values of t-statistics are significantly negative at 5% level of significance. So, according to ADF, all variables are stationary at first difference.

Phillips Perron (PP) test statistics

The results of the Phillips Perron (PP) are presented in Table 1b. The table reveals that at level form, estimated

Table 1b. Estimated values of Phillips Perron (PP) test statistics.

Variable name	At level form	At first difference
Yt	-0.30	-4.21
Kt	-1.50	-8.78
Lt	0.97	-6.14
ImpGcf	-2.37	-10.66
ExRnD	-0.56	-10.26
Hp	-0.49	-5.06
Hs	0.31	-5.37
Hh	-0.18	-5.90
Hu	-1.10	-6.21
Hvoc	0.11	-4.04

At 5% level of significance, critical value is -2.95.

Table 2. Johansen co-integration results.

Human capital	K_t	L_t	H_t
Primary H_P	0.36	0.18	0.79
Secondary H_s	012	1.27	0.27
College H_{col}	0.34	0.10	0.46
University H_{uni}	0.08	1.74	0.08
Vocational H_{voc}	0.02	1.56	0.25

Level of significance is 5%,

values of t-statistics for all variables are not significantly negative. Therefore, the data is not stationary at level form. The results of the differenced variables show that estimated values of t-statistics are significantly negative at 5% level of significance. So, all the variables are said to be integrated of order I (1).

Results of Johansen cointegration

Cointegration of two or more than two variables means that there exists a long run relationship between them. Johansen (1988) and Johansen and Juselius (1990) developed conintegration technique to test the long run relationship between variables. There are two basic criterion of Johansen conintegration results; trace statistics and Eigenvalue. If trace statistics and Eigenvalue is greater than critical value at 5%, then there exists long run relation between variables. In this study, for all equations, results of trace statistics and Eigen values reveal that there exists at least one cointegrating vector.

Empirical test 1: Impact of human capital on economic growth without technology

Tables 2 and 3 show that if we take technology as exogenously given, as according to Lucas (1988) idea, then our all education levels; primary, secondary, college, university and vocational training institutes show positive and significant impact on economic growth. As it is log linear form of Cobb Douglas production function so, coefficients are elasticities representing rate of change in growth rate as a result of change in respective level of education.

The results in Table 4 reveals that although primary, college and university level education have positive but insignificant impact on GDP in short run. Short run analysis shows secondary level education and vocational training have negative impact on GDP. The negative sign of ECM in case of secondary, college, university and vocational level education, indicates short run deviation will eventually converge towards the long run equilibrium path. There is a short run phenomenon that if we increase human capital through more years of schooling, then potential workforce may not able to join the labor market and there is reduction in per capita income. Hence short run results produced by ECM, may deviate from their long run behavior.

Empirical test 2: Impact of human capital on economic growth through technology

Tables 5 and 6 reveals that if we take technology factor as a variable factor with two proxy variables; expenditures on research and development and ratio of imports to gross fixed capital formation, then performance of secondary, university and vocational level human capital is enhanced, whereas with the inclusion of technology, performance of primary and college level, human capital deteriorates due to the inappropriate use of technology. Second important finding of this study is that technology not only enhances the performance of human capital, rather, it also improves the performance of capital and conventional labor. So we can deduce that reforms are required at our colleges so that use of technology may transform students into a useful and productive labor force.

The results in Table 7 show that except primary level education, all education levels have negative impact on economic growth in short run. The negative ECM coefficients for college, university and vocational level education reveal that, this short run deviation will converge towards long run equilibrium.

Conclusions

Although human capital positively affects economic growth in case of Pakistan, research and development and spillovers from R&D further enhances the performance of human capital at primary, secondary, university and vocational education levels. Hence, Romer's innovation driven growth mechanism is justified in case

Table 3. Elasticity of GDP w.r.t human capital with technology as exogenous factor.

Variable	Primary	Secondary	College	University	Vocational
Estimated coefficients	0.79	0.27	0.46	0.08	0.25
t-statistics	-9.00	-4.79	-4.21	-3.10	-4.74

Level of significance is 5%.

Table 4. The ECM estimates for human capital (short run dynamics for empirical test 1).

Regressors	Short run		Long run
	Coefficient	ECM	
$DlnH_p$	0.041 [0.64]	0.017	0.79 [-9.00]
$DlnH_s$	-0.0028 [-0.04]	-0.22	0.27 [-4.79]
$DlnH_{col}$	0.006 [0.422]	-0.11	0.46 [-4.21]
$DlnH_{uni}$	0.002 [0.15]	-0.15	0.08 [-3.10]
$DlnH_{voc}$	-0.03 [-1.04]	-.085	0.25 [-4.74]

Level of significance is 5%; D indicates differences of the variables used.

Table 5. Johansen co-integration results.

Human capital	K_t	L_t	H_t
Primary H_P	0.41	0.36	0.74
Secondary H_s	034	2.87	0.65
College H_{col}	0.65	4.21	0.21
University H_{uni}	0.31	3.46	1.37
Vocational H_{voc}	0.06	0.39	0.84

At 5% level of significance.

Table 6. Elasticity of GDP w.r.t human capital with technology as dynamic factor.

Variable	Primary	Secondary	College	University	Vocational
Estimated coefficients	0.74	0.65	0.21	1.37	0.84
t-statistics	-9.58	-4.96	-5.67	-3.79	-7.78

At 5% level of significance.

Table 7. The ECM estimates for human capital when technology is dynamic (short run dynamics for empirical test 2).

Regressors	Short run		Long run
	Coefficient	ECM	
$DlnH_p$	0.051 [0.77]	0.026	0.74 [-9.58]
$DlnH_s$	-0.06 [-0.88]	-0.09	0.65 [-4.96]
$DlnH_{col}$	-0.01 [1.05]	-0.03	0.21 [-5.67]
$DlnH_{uni}$	-0.005 [-0.37]	-0.09	1.37 [-3.79]
$DlnH_{voc}$	-0.004 [-0.42]	-0.01	0.84 [-7.78]

Level of significance is at 5%; D indicates differences of the variables used.

in case of Pakistan. As far as colleges working in public sector are concerned, performance of college level human capital deteriorates due to inappropriate use of technology. At college level, technology improves the performance of capital but not human capital. Vocational training institutes needs more attention because they are positively affecting economic growth but in a weak magnitude.

RECOMMENDATIONS

Teacher training programs refresher courses for primary and college level teachers must be started to enhance the capacity of teachers. In public sector educational institutions teacher assessment mechanism must be shifted from conventional ACRs written by head of institution to student's evaluation mechanism. Further, training workshops must be initiated for teachers working at public sector to induce rational thinking among students; it will facilitate to enhance social capital.

REFERENCES

Abbas Q, Foreman J (2008). Human Capital and Economic Growth: Pakistan. 1960-2003. Lahore J. Econ., 13(1): 1-27.

Barro RJ (1991). Human Capital and Growth. Am. Econ. Rev. Papers Proc., 91(2): 12-17.

Musibau BA, Rasak AA (2005). Long Run Relationship between Education and Economic Growth in Nigeria: Evidence from Johansen's Cointegration Approach. Cornel University, Dakar - Senegal.

Benhabib J, Spiegel MM (1994). The Role of Human Capital in Economic Development: Evidence from Aggregate Cross-Country and Regional U.S Data. J. Monet. Econ., 34(2): 143-173

Jones CI (2002). Introduction to Economic Growth. Second Edition. New York: Norton and Company.

Lucas RE Jr (1988). On the Mechanics of Economic Development. J. Monetary Econ., 22: 3-42

Lucas RE Jr (1990). Why doesn't Capital Flow from Rich to Poor Countries? Am. Econ. Rev., 80(1): 92-96

Mankiw NG, David R, David NW (1992). A Contribution to the Empirics of Economic Growth. Q. J. Econ., 107(2): 407-437

Mincer J (1974). Schooling, Experience and Earnings. NBER. NewYork.

Nelson RR, Phleps ES (1966). Investment in Humans, Technological Diffusion, and Economic Growth. Am. Econ. Rev. Proc., 56: 69-75

Romer P (1990). Endogenous Technological Change. J. Polit. Econ., 98(5): 71-102

Romer P (1990a). Human Capital and Growth: Theory and Evidence, Carnegie-Rochester Conference Series on Public Policy: Unit Roots. Investment Measures Other Essays, 32: 251-285.