Contributed Article

Human Capital Contributions to Economic Growth in India: An Aggregate Production Function Analysis

Jandhyala Viswanath, K L N Reddy & Vishwanath Pandit

Education is a merit as well as a public good and is associated with large sets of externalities which are often indirect, invisible and non-quantifiable. The modern theory of endogenous growth has brought this out very prominently. Using an aggregate production function approach, the present study estimates the contributions of human capital and physical capital to economic growth in India using cross section data for 26 Indian states and union territories relating to the years 1995-96 and 1998-99. Several alternative specifications of functional forms are estimated and most of them gave robust results. The important finding that emerges from this study is that a strong positive relationship exists between investments in human capital and economic growth.

Jandhyala Viswanath is Manager, Export Import Bank of India, Mumbai 400005 (Email: viswanath@eximbankindia.in). K.L.N. Reddy is Associate Professor, Department of Economics, Sri Sathya Sai University, Prasanthi Nilayam, Andhra Pradesh (Email: klnklnreddy@rediffmail.com). Vishwanath Pandit is Vice Chancellor, Sri Sathya Sai University (Email: vnpandit@gmail.com)

About the Study

Traditional economic theory generally viewed capital in physical terms only. Economists during the late 1950's, based on aggregate production function, found that the standard measures of simple labour and physical capital were incapable of explaining adequately the rapid post-War growth. Speculations on what were missing were diverse. Some argued that the principal explanation lays in the lack of appropriate adjustments for improvement in the quality of physical capital and the embodiment of technical progress in that capital. Others suggested that the most important omission pertains to the organizational advance or a vaguely specified "human factor". The "residual" of unexplained growth was at first ascribed to technology (Solow 1957). But later, the "residual" was defined to include improvements in the quality of capital (Denison 1962, Griliches & Jorgenson 1964) and the investment in human beings (Schultz 1959, 1961). Human capital is formed from investment in skills and education. Although Adam Smith did not specifically use the term "human capital", he included in the

category of fixed capital the skills and useful abilities of human beings. Marshall provided an elaborate account of estimating returns to human capital. But the contribution of Nobel laureate Theodore Schultz (1961) marks the beginning of the formal induction of human capital into the main stream of economic analysis. He stated '…investment in human capital accounts for most of the impressive rise in real earnings per worker.' The best-known application of the idea of "human capital" in economics is that of Mincer and Becker. Becker (1962) built on Schultz's work by developing a broader theory of human capital. In the early years of economics of education, controversy prevailed on the 'flower and seed' or the 'chicken and egg' relationship between education and economic growth (Vaizey 1962).

Education being a merit good and a public good is most often associated with a large set of externalities that are most often indirect, invisible and most importantly 'non-quantifiable'. Besides merely teaching and learning, education also encompasses something less tangible but more profound: the imparting of knowledge, good judgement, wisdom and above all inculcation of values in students and imparting of culture from generation to generation. Education promotes in individuals the ability to make moral, rational and ethical choices among alternatives and then act on them.

The non-quantifiability of the benefits accrued from education is responsible for it often not being included explicitly as an important factor or determinant of growth of an economy. Education variable in production functions implicitly consider the skills as well as the values it inculcates and the externalities it produces. The important role of education in imparting skill and abilities, enhancing labour productivity, overall well-being and eventually economic growth is being recognized. This study aims at empirically estimating the relative contribution of human capital and physical capital to economic growth in India based on an aggregate production function approach using OLS method. The study based on inter-state data in India pertains to two time periods namely 1995-96 and 1998-99. The selection of the sample period(s) has been mainly influenced by the availability of the data.

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Human Capital in Theories of Growth

Economists have observed that education contributes to economic growth for the country as a whole in the following ways (Miller 1967, Schultz 1963). First, education not only imparts knowledge but also changes people's perceptions and expectations of themselves and the society around them. Education may alter the attitude to work, consumption preferences, saving propensities, economic rationality, adaptability, inno-

vativeness, flexibility, attitude towards family size, and various social attitudes relevant from the economic point of view such as migration within countries and internationally, towards more productive sectors of the economy resulting in rise in GDP and per capita income. Second, education, through investment in human beings, imparts the knowledge to develop abundant complementary resources that may be substitutes for comparatively scarce resources and thus promotes efficient use of existing resources. Moreover, education is an alternative to consumption and not saving. Additional expenditure on education can make a net contribution to economic growth, even if the rate of return would be lower, because the investment made in education would otherwise be consumed. Further, education contributes to economic growth most essentially through research and also by discovering, cultivating, and nourishing potential talent. Lastly, as educational levels increase for women in developing nations, the opportunity cost to stay home and raise families rises. It increases labour force participation and reduces fertility rates for these women. Moreover, economists believe that educational poverty may lead to absence of growth in the economy. This realization has forced investment in education to increase at a rapid rate which itself may account for a substantial part of the otherwise unexplained rise in earnings.

Rate of Return Approach

Among many researches, Psacharopoulos (1972, 1994) observed that the rates of return to investment in human capital are well above those on physical capital in a large number of countries and it is highest in the case of primary education. Also, the returns to education in developing countries are higher relative to those in advanced countries. Harberger (1965) showed that both secondary and higher education yielded rates of return at least above 10 per cent. Nalla Gounden (1967) estimated that about 7 per cent of the growth of income in India was accounted for by education. Tilak (1987) has estimated in detail rates of return by levels of education, by caste groups, by gender and by rural and urban regions. The economic returns to education in India, according to Tilak, are estimated to be reasonably high. They are comparable to rates of return to investments in physical capital. They are also good in comparison with the rates of return to education in other developing and developed countries and they are found to be increasing. Duraisamy and Duraisamy (1995) also estimated rates of return to higher education, and Duraisamy (2002) estimated changing rates of return to education over a time period with the help of national level household surveys.

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Residual & Production Function Approaches

Another most important approach that has been frequently used by researchers to analyze the contribution of education to economic growth is the production function approach. In the beginning the unexplained proportion of economic growth in a production function, viz. the "residual" was treated as the contribution of education to economic growth. Solow (1957), Svennilson (1964) and Denison (1962) suggested that improvements in the quality of labour force, including increased education, were important together with other factors such as technological progress and economies of scale and constitute an important part of the residual. Later economists like Griliches and Jorgenson (1966) were also of the same opinion and argued that the residual was not "a coefficient of ignorance", as some critics (Balogh 1963) argued. Human capital, particularly education, forms a significant proportion of this residual. Though the residual was believed to comprise economies of scale, technological progress, external economies, improved health, education and skill of labour force, better management etc., it was also felt that among all education was as an important factor. With Denison (1962, 1964) and Griliches (1964, 1970) works, it was made clear that education could enter as an important variable (input) in the production function analysis of economic growth.

According to Bowman (1964), Psacharopoulos (1973), Denison (1979), Hicks (1980), Wheeler (1980), Marris (1982), Benavot (1985), Tilak (1986), Lau et al. (1991), World Bank (1993), Tilak (2003) though based on different methods, variables, data sets and sample periods for both developed and developing countries the import-ant role that primary, secondary and higher education play on economic develop-ment of a country is well recognized. Most of the cross-country regressions indicate that the change in education is positively associated with economic growth once measure-ment error in education is accounted for.

Economic efficiency in both physical and human capital and innovations through improvements in skill and technologies have been considered as the key sources of economic growth.

By adding research and development to the neoclassical growth model such that agents must allocate resources between producing goods and producing knowledge. The neoclassical model is generalized such that decisions to pursue knowledge are now endogenous. Economic efficiency in both physical and human capital and innovations through improvements in skill and technologies have been considered as the key sources of economic growth by the modern theory of endogenous growth, also called new growth theory. The endogenous growth models are a recent conceptualization and they have great significance in modern growth theories. This endogenous growth theory was

popularized primarily by Lucas (1990, 1993), Romer (1990, 1994). This new growth theory reduces the limitations of the neoclassical growth model by allowing increasing returns to scale through endogenous technological progress linked to human capital accumulation. Lucas (1988), Romer (1990), Barro (1991) have all reported significant positive effects of education on growth. Romer (1990) assumes that the growth of productivity depends on the existing stock of ideas and the number of individuals devoting their time to it. He also distinguishes human capital from the technology parameter. Barro (1999) found in his cross-country regressions on 100 countries that economic growth between 1960 and 1995 is positively related to the base level (1960) secondary and higher levels of education attainment of adult population.

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A few Indian studies were also conducted in this regard. In line with Denison's approach, Dholakia (1974) tries to quantify the contribution of education to economic growth in India and estimates it to be 14.01 per cent during 1948-49 to 1968-69. According to Psacharopoulos (1973) it was as high as 34.4 per cent. But Loh (1995) using 1971-81 data estimated the corresponding ratio to be 27 per cent. These estimates differ considerably from each other possibly due to differences in source data for the distribution of workers by education and the weighting system, and to some extent in the methodology. Using recent data in another inter-state analysis, Mathur and Mamgain (2004) also found significantly increasing effects of education on economic development (NSDP per capita) by increasing levels of education. Sivasubramonian (2004) also found significant positive impact of education on economic growth in India though he used time series data in his analysis.

The research that used production functions is not unanimous on the positive role of education in economic growth. A few researchers such as Bowman (1980), Islam (1995), Caselli et al. (1996), Barro and Sala-i- Martin (1995), Benhabib and Spiegel (1994) were of the opinion that either education does not contribute to economic growth at all or that its contribution to economic growth has been overemphasized. Most studies (Griliches 1997) however, note that measurement error in schooling or a tendency for more highly educated workers to enter the sectors of the economy whose contribution to GDP are systematically under measured could bias their results.

Aggregate Production Function

An aggregate production function approach is used in the present study to estimate the contribution of human capital to economic growth in India

using cross-section data. OLS method has been used for estimation of the aggregate production functions, which incorporate human capital as an explicit variable, along with physical capital.

The following semi-log regression equation is estimated in the study:

$$\text{Ln } Y_t = \alpha + \beta_1 \text{ PC} + \beta_2 \text{ HC}$$

where, Y represents Net State Domestic Product per capita; PC, physical capital measured in terms of productive capital; HC, human capital measured in terms of mean years of schooling, α, a constant term and β_1, β_2 regression coefficients.

Economists have used different measures with regard to the measurement of physical capital. The debate starts with the choice between gross values of physical capital and net values of physical capital to be considered. It has been pointed out that the use of gross figures of capital is justified in less developed countries on the ground that capital stock is often used at approximately constant level of efficiency for a period far beyond the accounting life measured by normal depreciation until it is eventually discarded or sold as scrap. Few studies have used gross fixed capital stock as capital input. Most of the studies have used perpetual inventory method and thereby overcome all deficiency. We consider per capita productive capital (PC) (i.e., the summation of working capital and fixed capital) as capital for our analysis.

Education is considered as the best indicator of human capital though as Knight (1996) noted, "Not all education produces human capital and, even more importantly, not all human capital is produced by education", but it still remains the most prominent indicator of human capital. Most often enrolment ratios and literacy rates have been used as alternative ways to measure the educational attainment but were however found to be inadequate and poor indicators as they do not make any distinction between various levels of education and treat all educated people of various levels alike.

There are quite a few important attempts made at constructing composite index of education development, with the help of simple methods as well as statistically sophisticated methods like principal component analysis and taxonomic methods (Tilak 1979, 1981a). More reliable and sophisticated measures are now available on human capital. Mean years of schooling is considered as the best indicator of the stock of human capital in a society and in recent years it has been used as also in this study. Psacharopoulos and Arriagada (1986, 1992), constructed this index, known as the 'mean years of schooling of the labour force', a stock measure based on educational levels of labour force, and years of schooling of each level of education. The latter is used as weights to the former. It may be argued that any measure of educational development might better take the population into account, and not just the labour force unless one is interested in the 'direct' contribution of the edu-

cated labour force only. Hence Tilak (1994) modified the index given by Psacharopoulos and Arriagada (1986), so as to cover the total population, and not just the labour force, as follows:

$$S = \sum Pi\ Si,$$

where, Pi is the percentage share of persons in the total population with the i-th level of schooling, and others are as defined above. The results/data are subject to statistical tests and they were found to be yielding robust results. The White's heteroscedasticity test was conducted on all the models and there was found to be no possibility of heteroscedasticity.

Sources of Data

This study uses data pertaining to the above macroeconomic variables of 26 Indian States and Union Territories obtained from RBI Handbook of Statistics on the Indian Economy 2004-2005 published by the Reserve Bank of India (RBI), Statistical Abstract of India and Annual Survey of Industries for productive capital, Tilak (1997) for mean years of schooling. The data on MYS for all the states and union territories in India, computed by Tilak is available only for the years 1971, 1981, 1992-93, 1995-96 and 1998-99. The selection of the sample years, 1995-96 and 1998-99, for analysis has been influenced by the availability of the state-wise data pertaining to the other variables (like productive capital) and the relevance, importance and applicability of the results to present as well as the future time periods. All data are based on information available up to December 2005.

Empirical Analysis

All the equations estimated (Table 1) are in semi logarithmic form. Out of the adjusted sample of 25 Indian states, 22 states are considered in the first 4 equations and 20 states are considered in equation 5. The independent variables or the regressors in all the models are per capita productive capital 1997 (PC97) and mean years of schooling 1998 (MYS98). NSDP from 1998 to 2002 are the regressands in the 5 equations respectively.

Table 1: Regression Results: I (using Mean Years of Schooling 1998)

(Ln NSDP = $\alpha + \beta_1$ PC + β_2 MYS)

Eqn No.	Dep Var	Const	PC97	MYS98	Adj R^2	N
1	LnNsdp98	0.79	0.06	0.24	0.684	22
		(2.85)	(3.67)	(3.98)		
2	**LnNsdp99**	**0.80**	**0.06**	**0.25**	**0.693**	**22**
		(3.00)	**(3.60)**	**(4.20)**		
3	LnNsdp00	0.78	0.052	0.27	0.655	22
		(2.72)	(2.91)	(4.23)		
4	LnNsdp01	0.80	0.05	0.27	0.658	22
		(2.78)	(2.96)	(4.22)		
5	**Ln LnNsdp02**	**0.72**	**0.06**	**0.28**	**0.726**	**20**
		(2.61)	**(3.44)**	**(4.64)**		

Note: Values in parenthesis indicate t-values

We conclude that both variables are significant though human capital turns out to be statistically more significant than physical capital in explaining the NSDP in all the equations.

Observing the t-statistic, we conclude that both variables are significant at 1% level of significance, though human capital turns out to be statistically more significant than physical capital in explaining the NSDP in all the equations. All equations have reasonably high adjusted R^2 between 0.66 and 0.73. We can thus conclude that in the above equations approximately 70 percent of the variation in NSDP is explained by the independent variables namely physical capital and MYS. We re-emphasize the point that our objective is not to model the NSDP and to find a best fit with a very good R^2, but to see the relative contributions of physical and human capital towards economic growth. For an in-depth analysis of the cross section regression results we shall deal with equation 2 and equation 5, as they are capable of giving a good picture of the entire model. Interpretations for the remaining equations can be made on similar lines.

In equation 2 there is an in-built lag effect of 2 years for physical capital and 1 year lag for human capital. In case of equation 5, there is in-built lag effect of 5 years for physical capital and 4 year lag effect for human capital. There is need to introduce a lag effect since both physical capital and human capital have a gestation period only after which they can start yielding significant returns.

Table 2: Regression Results: II (using Mean Years of Schooling 1995)

(Ln NSDP = α + β PC + β_2 MYS)

Eqn No.	Dep Var	Const	PC94	PC97	MYS95	Adjusted R-Square	N
6	lnNsdp95	0.85	0.06		0.22	0.689	26
		(4.41)	(3.10)		(5.53)		
7	**lnNsdp97**	**0.84**	**0.08**		**0.23**	**0.777**	**26**
		(4.89)	**(4.25)**		**(6.60)**		
8	lnNsdp02	0.81	0.09		0.26	0.805	22
		(4.39)	(4.00)		(6.94)		
9	**lnNsdp02**	**0.85**		**0.059**	**0.26**	**0.828**	**22**
		(4.94)		**(4.55)**	**(7.45)**		

Note: Values in parentheses indicate t-values

The signs of the coefficient in the two estimated equations are in accordance with economic theory, physical capital and human capital being positively related to GDP. According to equation 2, if there is 1 unit change in MYS there will be 0.25 % growth in NSDP one year later and for a 1 unit change in physical capital there will be 0.06 % growth in NSDP two years later.

According to equation 5, if there is 1 unit change in MYS there will be 0.28 % growth in NSDP four years hence and for a 1 unit change in physical capital there will be 0.06 % growth in NSDP five years later. In both the cases (equations 2 and 5) our results make it clear that physical capital does not have a more crucial role in determining growth of GDP than human capital. In fact, human capital has a stronger effect.

Physical capital does not have a more crucial role in determining growth of GDP than human capital.

All the equations estimated in Table 2 are in semi logarithmic form. Out of the sample of 26 Indian states, all 26 states are considered in equations 6 and 7 whereas 22 states are considered in the remaining two equations. The independent variables in all the models are per capita productive capital 1994 (PC94) and mean years of schooling 1995 (MYS95) except for equation 9 where PC97 is used instead of PC94. LnNSDP is the dependent variable in all cases. Here too we conclude that both variables are significant at 1% level of significance, though human capital turns out to be statistically more significant than physical capital in explaining the NSDP in all the equations. All equations have high adjusted R^2 between 0.70 and 0.83. Approximately 70 to 80 percent of the variation in NSDP is explained by the independent variables namely physical capital and human capital, which is considered a good measure. We can infer that these two types of capital are capable of explaining a major portion of the variation in NSDP.

For a detailed analysis of the results on physical and human capital and to draw comparisons we shall consider equation 7 and equation 9. Interpretations for the remaining equations can be made on similar lines. In equation 7 there is an in-built lag effect of 3 years for physical capital and 2 years lag for human capital. In case of equation 9, there is in-built lag effect of 5 years for physical capital and 7 year lag effect for human capital. In order to account for the gestation period involved in physical and human capital these lags are introduced.

The signs of the coefficient in all the estimated equations are in accordance with conventional beliefs that as physical capital and human capital increase, NSDP also increases. According to equation 7, if there is 1 unit change in MYS there will be 0.23 % growth in NSDP two years later and for a 1 unit change in physical capital there will be 0.08 % growth in NSDP three years later and in case of equation 9, if there is 1 unit change in MYS there will be 0.26 % growth in NSDP seven years later and for a 1 unit change in physical capital there will be 0.06 % growth in NSDP five years later. Thus the impact of human capital on growth of NSDP seems to be more than that of physical capital contradictory to the traditional notion that human capital is not a very significant variable in the determination of economic growth in an economy and that physical capital has a more vital role.

The impact of human capital on growth of NSDP seems to be more than that of physical capital.s

Conclusions

The pioneering works of Schultz, Denison, Becker, Mincer, Barro, Romer, Lucas and others, have highlighted the role of human capital as an important source of economic growth. Education in particular has been deemed as the most important component of human capital. The analysis of human capital is still fraught difficulties like measurement and quantification. Through four decades of work on human capital (notably by Denison, Schultz, Becker and Lucas among others), these problems are partly solved and economists came to recognise the significant relationship between human capital formation and economic growth.

This study, attempted to empirically estimate the relative contribution of human capital and physical capital to economic growth in India, using an aggregate production function approach incorporating human capital as an explicit explanatory variable, along with physical capital. In the measurement of output and physical capital, per capita net state domestic product (NSDP) and Per capita productive capital (PCAP) respectively are considered in our analysis. Mean years of schooling, which is considered as the best indicator of educational attainment has been used in our analysis. A time lag has been introduced, in order to account for gestation period in both forms of capital. Such quantitative analyses cannot consider many non-quantifiable but very important aspects of human capital, such as the values in education, the quality and attitudinal changes that education brings in etc. This is an important limitation of the present study also. To the extent that some important facets are left out the real contribution of education to economic growth and more widely welfare remains understated.

The overall conclusion that emerges from this study is that a strong positive relationship exists between investments in human capital and economic growth. Human capital (or educational attainment as measured by MYS) appears to be a significant element in explaining increase in production in India, even after controlling for physical capital. Our results are quite robust across alternative specifications of the functional form and cross section data sets.

Barro and Lee (1996) and Neruh et al. (1995) have made estimates of mean years of schooling of population over 15 years in various regions of the world which is summarized in Table 3.

Table 3: Average School Year of Education

	Barro and Lee		Neruh et al.
AREA	1970	1990	1987
Developing Countries	2.66	4.43	4.48
Middle East and North Africa	2.05	4.47	4.79
Sub-Saharan Africa	2.06	2.93	2.54
Latin America	3.82	5.24	5.52
East Asia and South Pacific	3.80	6.08	5.13
South Asia	2.03	3.85	3.39
OECD	7.58	9.02	10.0

Source: Barro and Lee (1996), population over 25. Neruh et al. (1995), population between the ages 15-64.

The mean years of schooling for India for the year 1995-96 is 4.26 (Tilak 2005). The estimates for India for 1995-96 are higher than only those of the Sub-Saharan African region and the South Asian region for 1990. This portrays a very dismal picture of the state of education in India and reflects the urgency with which this serious issue needs to be addressed. Having observed the important role that education plays in the growth of an economy the implication is clear: for India to grow and develop, it must accord due importance to its human capital resources rather than just focusing only on its physical capital. Government has to focus on expanding all levels of education with quality.

To conclude we would like to draw attention to a Chinese proverb, which beautifully sums up the importance of education in development:

> "If you are planning for a year, grow rice and vegetables;
>
> If you are planning for decades, grow trees.
>
> But, if you are planning for centuries, educate children."

To add to the proverb,

If you are planning for sustained and all-round development for centuries, don't merely educate children but mould them into men of character and faith.

This is possible only with heavy public investment in a system of high quality education with human values. Education with human values will pay higher dividends not only to the individuals, but also to the whole society.

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