Estimates of the Level and Growth Effects of Human Capital in India

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ABSTRACT

While Mankiw, Romer and Weil (1992) argue that human capital has only permanent level and not permanent growth effects on output growth, others (Lucas, 1988 and 1990 and Benhabib and Spiegel, 1994) treat human capital as growth improving variable. But the literature is silent on if human capital has both a permanent level and a permanent growth effects because it is not known how in practice such effects can be estimated. Taking India as an example from 1970 – 2007, we show that both the level and growth effects of human capital can be estimated with a further extension to the Solow model.

Keywords: Human capital, Solow model and Country Specific Steady State Growth Rate

JEL classification: J24, O4, O53

1. Introduction

In the empirical literature on growth the role of human capital (*H*) is interesting. In the well known extension to the exogenous growth model of Solow (1956) Mankiw, Romer and Weil (1992, MRW hereafter) have treated *H* as an additional factor of production. Therefore, *H* has only permanent level effects on per worker output and no permanent growth effects. With this modification MRW have argued that the Solow model can explain observed facts as well as the endogenous growth models. On other hand *H* is treated as a growth improving policy variable in the endogenous models. Lucas (1988 and 1990) and Benhabib and Spiegel (1994) discuss the channels through which *H* can improve the growth rate. However, the literature is silent on if *H* has both a permanent level and a permanent growth effect because it is not known how in practice such effects can be estimated. This paper shows that both the level and growth effects of *H* can be estimated with a further extension to the Solow model. For illustration we shall use data from India from 1970 to 2007.

2. Specification

Let the Cobb-Douglas production function, with constant returns, be as follows.[1]

$$Y_t = A_t K_t^{\alpha} (H_t \times L_t)^{(1-\alpha)} \quad (1)$$

where *Y* = output, *A* = stock of knowledge, *K* = stock of capital, *H* = an index of human capital formation through education and *L* = employment. This gives the following intensive form of the production function.

$$y_t = A_t k_t^{\alpha} \quad (2)$$

where $y = (Y / H \times L)$ and $k = (K / H \times L)$. In equation (2) the variables are measured in per worker terms adjusted for skill improvement. To estimate (1) or (2) it is first necessary to check the time series properties of the variables Y, K, LH, y and k. We have conducted the *ADF*, *KPSS* and *DF-GLS* tests to find that these variables are $I(1)$ in levels and $I(0)$ in their first differences. To conserve space these results are not reported here but can be obtained from the authors.

[1] This is slightly different from the one used by MRW where labour (*L*) and *HK* are separated but helps to increase the degrees of freedom in estimation.

The steady state properties of the Solow model are well known where the steady state level of output (y^*) is given by

$$y^* = \left(\frac{s}{d+g+n} \right)^{\frac{\alpha}{1-\alpha}} A \qquad (3)$$

$$\therefore \Delta \ln y^* = \Delta \ln A \qquad (4)$$

where α is the share of profits, s is the investment rate, d is the rate of depreciation, g is the growth rate and n is the rate of growth of population. Since the parameters s, g, n, d and α remain constant in the steady state the steady state rate of growth of output equals the rate of growth of the stock of knowledge. Thus the steady state growth rate in MRW's extended Solow model is the same as in Solow's (1956) original model and H does not have any permanent growth effects. The level effects of H on per worker income are as follows:

$$\left(\frac{Y}{L} \right) = \left(\frac{s}{d+g+n} \right)^{\frac{\alpha}{1-\alpha}} A \times H \qquad (5)$$

The Solow model can be extended to estimate both the level and growth effects as follows. For this purpose we can assume that the stock of knowledge A_t evolves with time (t) as follows.

$$A_t = A_0 e^{gt} \qquad (6)$$

where A_0 is the initial stock of knowledge and g is its growth rate. If H has also some permanent growth effects, (6) can be extended by assuming that $g = f(H)$ and a linear specification is as follows.

$$A_t = A_0 e^{(g_0 + g_1 H_t)t} \qquad (7)$$

where g_0 captures the growth effects of trended but ignored variables and g_1 is an estimate of the growth effects of H. With these modifications the production function in (2) can be written as follows.[2]

[2] This specification was originally developed by Rao and used in his several empirical works on the growth models; see below for some references.

$$y_t = A_0 e^{(g_0 + g_1 H_t)t} \; k_t^{\alpha}$$
$$\therefore \ln y_t = \ln A_0 + (g_0 + g_1 H_t)t + \alpha \ln k_t \qquad (8)$$

Equation (8) can now be estimated with a nonlinear method.

3. Empirical Results

We shall use the London School of Economics approach, known as the general to specific method (*GETS*), for the estimation of (8). Professor David Hendry is its most ardent exponent and supporter.[3] The general *GETS* specification for (8) is as follows.

$$\Delta \ln y_t = -\lambda[(\ln y_{t-1} - (a_0 + (g_0 + g_1 H_{t-1})t + \alpha \ln k_{t-1})]$$
$$+ \sum_{i=0}^{n1} \gamma_i \Delta \ln k_{t-i} + \sum_{i=0}^{n2} \tau_i \Delta H_{t-i} + \sum_{i=1}^{n3} \eta_i \Delta \ln y_{t-i} \qquad (9)$$

A parsimonious version of (9) can be derived by deleting the insignificant lagged changes in the variables and this is a well known procedure in the estimation of the short run dynamic equations from the cointegrating equations. Parsimonious estimates of alternative specifications of (9) are given in Table 1 for India for the period 1973 to 2007. These estimates are made with the non-linear two stage least squares method with the internal instrumental variables option (NL2SLSIV). Definitions of the variables and sources of data are in the Appendix.

Prior to an examination of the estimate it is necessary to note some difficulties in estimating a production function for India. To the best of our knowledge estimates of an aggregate production function for India do not exist. Recently, in an influential growth accounting exercise for India, Bosworth and Collins (2008) have assumed that the share of profits (α in (8)) to be 0.4 instead of estimating this parameter with a production function. The main problem in estimating a production function for India seems to be due to large negative shocks caused by frequent monsoon failures, wars with Pakistan, bad economic policies due to regulation and bureaucracy, known as the license Raj, and some political instability due to the emergency rule during 1978-1979 and the uncertain outcome of the elections of 2004.

[3] *GETS* has been extensively used in the empirical works of Rao and Singh (2005) for the demand for money, Rao and Rao (2009a), Rao, Gounder and Loeining (2009) and Rao, Tamazian and Vadlamannati (2009) for growth models and Rao and Rao (2009b) to estimate the demand for gasoline. Rao, Sing and Kumar (2009) defend *GETS* approach over time series methods.

We have added dummy variables for these shocks but found that in most cases three dummy variables viz., *DUM79, DUM91* and *DUM04* are significant. *DUM79* is to capture the adverse effects of the emergency rule and *DUM91* is for the economic crisis of 1991 after which India has devalued its currency and implemented liberalisation policies under the pressure of the World Bank and IMF. *DUM04* captures a somewhat smaller negative shock caused by the uncertain 2004 election outcome and the change of government. It was not significant in some regressions.

Estimates without the growth effects for *H* but with only its level effects are given in column (1) of Table 1. This equation is estimated with a correction for first order serial correlation, which is -0.5 and significant. The other summary statistics for misspecification (χ_{ff}) and non-normality of residuals (χ_{nn}) are significant only at about 70% and the adjusted R-Bar square is high at 0.812. The Sargan test indicates that the selected instruments are valid. The two dummy variables for negative shocks viz., *DUM79* and *DUM91* are significant but *DUM04* was insignificant (not shown). However, the estimate of profit share α at more than 75% seems to be high and significant only at 10% and the coefficient of autonomous *TFP* is insignificant. The high estimate for α may be partly due to the neglect of the growth effects of *H.*

To reduce the size of the level effects of *H,* we reestimated this equation by assuming first that $\alpha = 0.4$ as by Bosworth and Collins and second $\alpha = 0.33$, which is its stylised value in many growth accounting exercises. These estimates are in columns (2) and (3) respectively. Their summary statistics are as good as those for the equation in column (1) but the R Bar squares are reduced. The serial correlation test indicates that it is absent at the 5% level in both equations. *DUM04* and autonomous *TFP* have now become significant and the latter indicates that the long run growth rate of the Indian economy is about 2%. Both equations have similar statistical properties but we prefer the one in column (3) because the assumed value for α is widely used in the growth accounting exercises.

To estimate both the level and growth effects of *H,* we estimated our modified specification in (8) and (9) first with the assumption that α equals 0.4 and then 0.33 as in the two earlier estimates with only level effects. Both gave very similar results and to conserve space only the latter is reported in column (4). The summary statistics of this equation are similar to the one in column (3) except that (a) serial correlation in its residuals is significant at the 5% but not at the 1% level; (b) the coefficient of autonomous *TFP* (g_0) is negative and insignificant;

(c) the coefficient of $\Delta^2 \ln k_t(\gamma_1)$ is insignificant and most importantly (d) the growth effect of $H(g_1)$ is significant and estimated to be 1.6%. When this equation is reestimated with first order serial correlation transformation the first order serial correlation coefficient (ρ_1) was insignificant even at the 10% level and this is not reported to conserve space.

Since the coefficient of autonomous *TFP* is insignificant, this equation is reestimated with the constraint that $g_0 = 0$. Furthermore, we have removed the constraint that $\alpha = 0.33$ and reestimated our specification of level and growth effects. This is shown in column (5) and its summary statistics are very similar to those in columns (2) to (4). The noteworthy feature of this estimate is that both the level and growth effects of *H* are significant. The latter is about 1.5% per year and the level effect of *H* with an elasticity of 0.65 is consistent with the assumed values for the share of profits in many growth accounting exercises. When this equation was reestimated correcting for first order serial correlation ρ_1 was insignificant. These estimates are not reported to conserve space. Although the summary statistics of the estimates of the equations in columns (2) to (5) are very similar, the estimate of our modified specification in column (5) is preferred because it can explain both the level and growth effects of *H*.

4. Conclusion

In this paper we have shown that the Solow (1956) growth model can be extended to estimate both the level and growth effects of human capital. This is an improvement because only one of these two effects is estimated in the existing empirical works such as Mankiw, Romer and Weil (1992). Our estimates for India showed that the elasticity of the level of output with respect to human capital is about 0.65 and that human capital formation permanently increases the rate of growth of output. The sample average value of *H* was 1.131, implying that the contribution of *H* to India's growth rate was 1.7%. If this average is increased by 20%, then the permanent growth rate in India will increase to 2%. There are some limitations in our study of which the most important is the insignificance of the effects of other neglected growth enhancing variables like trade openness, investment ratio and reforms etc. Hopefully other investigators will pay attention to these gaps.

Tables

Table – 1 Level and Growth Effects of Human Capital for India Dependent variable: $\Delta \ln y$ NL2SLS IV Estimates, 1973-2007					
Models	**1**	**2**	**3**	**4**	**5**
Intercept (a_0)	-1.841 (-1.145)	-3.036 (-93.497) **	-3.322 (-101.063) **	-3.287 (-124.524) **	-3.241 (-5.578) **
$\ln y_{t-1}(\lambda)$	-0.112 (4.974)**	0.133 (3.947) **	0.135 (3.867) **	0.173 (3.920) **	0.173 (3.887) **
$t\ (g_0)$	0.007 (0.577)	0.019 (7.061) **	0.021 (8.173) **	-0.001 (-0.1698)	0.015 (4.245) **
$H_{t-1} \times t\ (g_1)$				0.016 (3.027) **	
$\ln k_{t-1}\ (\alpha)$	0.755 (1.891)*	0.4 (c)	0.33 (c)		0.343 (2.351) **
$\Delta^2 \ln k_t(\gamma_1)$	0.866 (15.254)**	0.137 (2.270) **	0.128 (2.126) **	0.007 (0.059)	0.017 (0.148)
$\Delta \ln k_{t-1}(\gamma_2)$	0.935 (20.022)**				
DUM71	-0.098 (-31.496)**	-0.101 (-34.645) **	-0.101 (-34.434) **	-0.103 (-35.830) **	-0.103 (-36.549) **
DUM91	-.0479 (-12.780)**	-0.049 (-16.203) **	-0.049 (-16.294) **	-0.049 (-16.792) **	-0.049 (-18.624) **
DUM04		-0.086 (-11.345) **	-0.087 (-11.909) **	-0.094 (-13.934) **	-0.093 (-12.515) **
$\bar{R}^2$	0.812	0.701	0.702	0.707	0.705
Sargan's χ^2	3.132 [0.680]	7.420 [0.284]	7.289 [0.295]	5.057 [0.409]	5.079 [.406]
SEE	0.015	0.018	0.018	0.0180	0.0180
ρ_1	-0.501 (-2.835)**	-----	-----	-----	-----
$\chi^2(sc)$	----	3.302 [0.069]	3.387 [0.066]	4.899 [0.027]	4.841 [0.028]
$\chi^2(ff)$	0.172 [0.678]	0.042 [0.838]	0.062 [.803]	0.615 [0.433]	0.105 [0.746]
$\chi^2(n)$	0.606 [0.738]	3.973 [0.137]	3.840 [0.147]	1.204 [0.548]	1.359 [0.507]

Notes: *t*-ratios (White-adjusted) are in the parentheses below the coefficients; 5% and 10% significance are denoted with ** and * respectively; *p*-values are in the square brackets for the χ^2 tests; constrained estimates are denoted with (c).

Data Appendix

Indicator	Source
Y is the real GDP at constant 2000 prices (in millions and national currency)	Data are from the World Development Indicator CD-ROM 2002 and new WDI online. URL:http://www.worldbank.org/data/onlinedatabases/onlinedatabases.htm
L is labour force or population in the working age group (15-64), whichever is available	Data obtained from the World Development Indicator CD-ROM 2002 and new WDI online. URL:http://www.worldbank.org/data/onlinedatabases/onlinedatabases.html
K is real capital stock estimated with the perpetual inventory method with the assumption that the depreciation rate is 4%. The initial capital stock is assumed to be 1.5 times the real GDP in 1969 (in million national currency).	Investment data includes total investment onfixed capital from the national accounts. Data are from the World Development Indicator CD-ROM 2002 and new WDI online. URL:http://www.worldbank.org/data/onlinedatabases/onlinedatabases.html.
Human Capital Index	Index of human capital formation through education obtained from Bosworth & Collins (2003).
DUM79 is one in 1979 and zero in all other periods to capture the adverse economic effects of emergency rule.	Own estimates
DUM91 is one in 1991 and zero in all other periods to capture the negative impact of economic and political crisis.	Own estimates
DUM04 is one in 2004 and zeros in all other periods change in government creating policy and political uncertainty.	Own estimates

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