Estimates of the level and growth effects of human capital in India

Rao, B. Bhaskara and Vadlamannati, Krishna Chaitanya

University of Western Sydney, University of Goettingen, Goettingen, Germany

24 September 2009

Estimates of the Level and Growth Effects

of Human Capital in India

B. Bhaskara Rao
School of Economics and Finance
University of Western Sydney, Sydney, Australia
raob123@bigpond.com

and

Krishna Chaitanya Vadlamannati
Development Economics & International Economics
University of Goettingen, Goettingen, Germany
kcv_dcm@yahoo.co.in

ABSTRACT

In the extended Solow growth model of Mankiw, Romer and Weil (1992) human capital has only permanent level and no growth effects. In the endogenous growth models human capital is a growth improving variable. Human capital may have both a permanent level and a permanent growth effect. We show, with data from India, that both the level and growth effects of human capital can be estimated with an extension to the Solow model.

Keywords: Solow model, Level and growth effects of human capital and India

JEL: 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]

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

where Y = output, A = stock of knowledge, K = stock of capital, H = an index of human capital formation through education and L = employment. The intensive form of (1) is:

$$y_t = A_t k_t^{\alpha} \tag{2}$$

where $y = (Y / H \times L)$ and $k = (K / H \times L)$. In (2) the variables are in per worker terms adjusted for skill improvement. To estimate (1) or (2) it is 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 are $I(1)$ in levels and $I(0)$ in their first differences. To conserve space these results are not reported but obtained from the authors.

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

[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.

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

$$\text{and } \Delta \ln y^{*}=\Delta \ln A \tag{4}$$

where α = share of profits, s = investment rate, d = depreciation rate, g = growth rate and n = rate of growth of population. Since s, g, n, d and α remain constant in the steady state the steady state rate of growth of output equals total factor productivity (*TFP*). 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 is as follows:

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

However, the Solow model can be extended to estimate both the level and growth effects as follows. We can assume that the stock of knowledge A_t evolves over time (*t*) as follows.

$$A_t = A_0 e^{gt} \tag{6}$$

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

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

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 (2) will be:[2]

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

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

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

3. **Empirical Results**

We shall use the London School of Economics approach, known as the general to specific method (*GETS*), for estimating (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 estimation it is necessary to note some difficulties in estimating a production function for India since to the best of our knowledge they do not exist. Recently, in an influential growth accounting exercise for India, Bosworth and Collins (2008) have assumed that $\alpha = 0.4$ instead of estimating this parameter with a production function. The main problem seems to be due to large negative shocks caused by monsoon failures, wars with Pakistan, bad economic policies due to regulation and bureaucracy, the license Raj, and some political instability due to the emergency rule during 1978-1979 and the uncertain outcome of the elections of 2004. We have added a few 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.

[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.

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 2 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 by 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

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)	0.33 (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).

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.

Data Appendix

All data from 1970-2003 are from the database of Bosworth and Collins (2008). From 2004 to 2007 these variables are computed from the sources indicated in the parentheses.

Y = GDP in National currency 2000 Constant prices (2004 to 2007 from WDI, 2008)

K = National currency 2000 Constant prices (2004 to 2007 investment data are from WDI, 2008 and K is computed with the perpetual inventory method)

L = Labour force (2004 to 2007 from WDI, 2008)

Inflation = Rate of change in GDP Deflator (2004 to 2007 from WDI, 2008)

H = Human Capital (2004 to 2007 proxied with the Secondary School Enrolment Ratio of the Ministry of HRD, Govt. of India)

References

Benhabib, Jess and Mark M Spiegel (1994) The Role of Human Capital in Economic Development: Evidence from Aggregate Cross-Country Data, *Journal of Monetary Economics*, 34, 143-173

Bosworth**,** Barry, and Susan M. Collins (2008) Accounting for Growth: Comparing China and India, *Journal of Economic Perspectives*, 22(1), 45–66.

Lucas, R. E. (1988) On the Mechanics of Economic Development, *Journal of Monetary Economics*, 22(1), 3-42.

Lucas, R. E. (1990) Why Doesn't Capital Flow from Rich to Poor Countries?, American *Economic Review*, 80(2), 92-96.

Mankiw, N. G., D. Romer and D. N. Weil (1992) A Contribution to the Empirics of Economic Growth, *Quarterly Journal of Economics*, 107(2), 407-437.

Rao, B. B. and Singh, R., (2006) “Demand for money in India: 1953-2003", *Applied Economics*, 319–1326.

Rao, B. B. and Rao, M. (2009) Exports and Determinants of Growth Rate: Some Evidence with Time Series Data from Fiji, *Applied Economics,* 41(13), 1653-1662

Rao. B. B., Tamazian, A. and Vadlamannati, K. C., (2009, forthcoming) Growth Effects of a Comprehensive Measure of Globalization with Country Specific Time Series Data, *Applied Economics*, 42(1), 1-18.

Rao, B. B., Singh, R. and Kumar, S. (2009, forthcoming) Do we need time series econometrics? *Applied Economics Letters.*

Rao, B. B., and Rao, Gyaneshwar (2009) Cointegration and the Demand for Gasoline, *Energy Policy*, 39, 3978-3983.

Solow, R. (1956) A contribution to the theory of economic growth, *Quarterly Journal of Economics,* 70(1), 65-94.