Panel data estimates of the growth and level effects of human capital in the selected Asian countries

Rao, B. Bhaskara and Singh, Rup

University of Western Sydney, University of the South Pacific

9 December 2009

1821 words

Panel Data Estimates of the Growth and Level effects of Human Capital in the Selected Asian Countries

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

Rup Singh
School of Economics
University of the South Pacific, Fiji

Abstract

This paper uses an extension to the Solow growth model to estimate the level and growth effects of human capital. Empirical results for a panel of 10 Asian countries from 1960-2003 show that both the growth and level effects of human capital are positive and significant.

Keywords: Level and growth effects of human capital, extension to the Solow growth model.

JEL: O4, O53

1. Introduction

In the endogenous growth models human capital (H) is growth enhancing (Lucas, 1988) but in the well known extension to the exogenous growth model of Solow (1956) by Mankiw, Romer and Weil (1992, MRW henceforth) H has only permanent level effects. In practice, however, H may have both level and growth effects. Therefore, recently Rao and Vadlamannati (2009) have extended the Solow (1956) growth model to show that how both these effects of H can be estimated. Their estimates for India, with time series data from 1973-2007, show that H has significant and positive level and growth effects. They found that while the elasticity of the level effects with respect to H was 0.65, its growth effects, at the mean value of H, is 1.7%. The main objective of the present paper is to test the usefulness of the Rao and Vadlamannati extension with data of a panel of 10 Asian countries. Our sample includes India, China, Bangladesh, Singapore, South Korea, Hong Kong, Indonesia, Malaysian, Thailand and Philippines from 1960-2003. The next section briefly discusses the specification and estimation issues. Section 3 presents and discusses empirical results and Section 4 concludes.

2. Specification and Estimation

While MRW and many cross country studies have used pure cross section methods to estimate the steady state level of output, we shall use both the time series and cross section observations for estimation. Thus the number of observations in our sample is large at 440 and therefore yields more efficient estimates. Rao (2010) and Rao and Vadlamannati (2009) have argued that since annual data on output and its growth rate are not satisfactory proxies for their unobservable steady state values, what can be estimated with such annual observations is the underlying Cobb-Douglas (CD) production function in the Solow growth model.[1] The CD production function can be extended to estimate the level and growth effects of variables like H as

[1] The interested reader may refer to the above works for a justification.

follows. Let the CD production function, adjusted for labour skills due to human capital formation with the Hicks neutral technical progress, be:[2]

$$Y = AK^{\alpha}(HL)^{1-\alpha} \qquad (1)$$

where Y, L, K and H denote output, factors inputs of raw labour, physical and human capital, respectively. A is an index of technology. The above can be written in its intensive form as:

$$y_t = A_t k_t^{\alpha} \qquad 0<\alpha<1 \qquad (2)$$

where $y_t = \frac{Y}{H \times L}$ and $k = \frac{K}{H \times L}$ are skills adjusted output and capital per worker. In many empirical works the evolution of technology in the Solow model is assumed to be

$$A_t = A_0 e^{gT}. \qquad (3)$$

where A_0 is the initial stock of knowledge and g is the steady-state growth rate of output or the rate of growth of total productivity (*TFP*). We are of the view that it is also plausible to assume that $A_t = f(T, H_t .....)$. Thus, the permanent growth effects of H can be captured with a few alternative specifications and a simple linear specification is:[3]

$$A_t = A_0 e^{(g_1 + g_2 \ln H_t)T} \qquad (4)$$

---

[2] The assumption of Hicks neutral progress instead of the Harrod neutral technical progress simplifies estimation. Estimates of the modified production function can be used to derive the unobservable steady state level of income and its growth rate; see Rao and Singh (2007), Rao (2010) and Rao and Vadlamannati (2009).

[3] See Rao and Singh (2007) for some alternative specifications for the long run growth effects of trade openness.

This implies that (2) can be transformed to capture the growth effects of human capital into:

$$y_t = A_0 e^{(g_1 + g_2 \ln H_t)T} k_t^{\alpha}$$

$$\therefore \ln y_t = \ln A_0 + [g_1 + g_2 \ln H_t]T + \alpha \ln k_t \qquad (5)$$

where g_1 measures the effects of other ignored but trended growth enhancing variables and g_2 shows the effect of H on the steady state growth rate of output. With data from 1970-2003 for the 10 countries (i = 10, t = 44), we shall estimate equation (5) with the conventional panel data methods and also with a system generalized method of moments (*SGMM*). *SGMM* has the merit of minimizing the endogenous variable bias and the weak instruments problem. Bond, Hoeffler and Temple (2001) has a useful discussion of the merits of *SGMM* in estimating growth models. We use Bosworth and Collins (2003) data details of which are in the appendix.

3. Empirical Results

We present estimates with the conventional and *SGMM* panel data methods in Table 1 below. In columns (1) to (3) estimates of the standard Solow model with the assumption that *TFP* evolves according to equation (3) are given. The panel data methods used are the population averages in column (1) and the fixed effects estimates in column (2) and the random effects estimates in column (3). All the 3 estimates gave similar results. The share of profits is about 0.28 and autonomous *TFP* is 2%. However, the Breusch-Pagan (BP) test showed that the random effects model in column (3) is preferable; see Notes to Table 1.

In columns (4) to (6) the extended Solow model in equation (5) is estimated with these 3 standard panel data methods. Estimates of autonomous *TFP* have decreased to 1.7% and H is found to have a permanent growth effect of 0.7%. Estimates of the share of profits remained the same at about 0.28. The BP test statistic indicated again that the random effects estimates in column (6) are

Table-1: Panel Estimates
Level and Growth Effects of Human Capital
1960-2003

	SOLOW MODEL			**EXTENDED SOLOW MODEL**				
	Population Average 1	Fixed Effects 2	Random Effects 3	Population Average 4	Fixed Effects 5	Random Effects 6	Random Effects 7	System GMM 8
Const.	-0.042 (0.46)	-0.042 (0.00)	-0.042 (0.49)	-0.070 (0.25)	-0.070 (0.00)	-0.070 (0.27)	-0.117 (0.00)	-0.196 (0.02)
$\ln\left(\frac{K}{H \times L}\right)$	0.280 (0.00)	0.282 (0.00)	0.281 (0.00)	0.280 (0.00)	0.282 (0.00)	0.280 (0.00)	0.234 (0.00)	0.222 (0.00)
T	0.020 (0.00)	0.020 (0.00)	0.020 (0.00)	0.017 (0.00)	0.017 (0.00)	0.017 (0.00)	0.020 (0.00)	0.014 (0.00)
$\ln\left(\frac{H}{L}\right)\times T$				0.007 (0.10)	0.007 (0.08)	0.007 (0.09)	0.015 (0.00)	0.016 (0.07)
$GRAT \times T$							-0.003 (0.00)	
$TRAT \times T$							0.005 (0.12)	
$\bar{R}^2$	---	0.910	0.841	---	0.910	0.838	0.882	0.991

Notes:

1. We used H as a ratio of L as opposed to H itself to be consistent with other ratio variables on which *TFP* is made to depend.
2. STATA-11 is used for estimation, except for the SGMM estimates which are from TSP. STATA could not invert the matrix of *SGMM* estimates due to multi-colinearity.
3. In the *SGMM* estimates the first order serial correlation in the levels equation was found to be near unity. To achieve convergence this parameter is assumed to be 0.995 in the levels equation.
4. The p-values are reported in parenthesis below the coefficients.
5. Breusch-Pagan Lagrangian Multiplier Test for random effects in III, VI, VII rejected the null in all cases. The p-values for the $\chi^2(1)$ LM tests are strictly zero.
6. TSP output does not compute the *SGMM* correlation coefficient statistic. Therefore, the $\bar{R}^2$ for the levels equation is reported.

preferable. We have reestimated this specification by adding additional growth enhancing variables as control variables and these are the ratio of government expenditure to *GDP* (*GRAT*) and a measure of trade openness (*TRAT*), measured with the ratio of the sum of exports and imports to *GDP*. To conserve space we report only the random effects estimates in column (7). Addition of these variables has made some changes. The share of profits decreased to 0.23, that of autonomous *TFP* has increased to 2% and the growth effects of H has increased significantly to 1.5%. This latter effect is close to the estimate of Rao and Vadlamannati of 1.7% for

India. Although *GRAT* and *TRAT* have the expected negative and positive signs, only the coefficient of *GRAT* is significant at the 5% level. The coefficient of *TRAT* is significant only at 12% level. Both have a small permanent growth effects.

Finally, in column (8) *SGMM* estimates of equation (3) are presented. When we have added the 2 control variables, the coefficient of neither *GRAT* nor *TRAT* is significant although they are of the correct signs. This may be due to their small growth effects and some endogenous variable bias that is ignored in the conventional panel data methods. To conserve space we reported only *SGMM* estimates without *GRAT* and *TRAT* in column (8). In any case the growth effects of these omitted variables are partly captured by the trend variable. These *SGMM* estimates imply that the autonomous *TFP* is 1.4% and the permanent growth effects of H are 1.6%, which is again close to the estimate of Rao and Vadlamannati estimate of 1.7% for India. The estimate of the share of profits at 0.22 implies that the elasticity of the level of output with respect to H is 0.22. These are reasonable the implications of our preferred estimates with *SGMM*.

5. Conclusions

Our estimates with panel data methods of the extended Solow growth model showed that human has both permanent level and growth effects. The permanent growth effect of human capital is found to be 1.6% for the 10 Asian countries. Furthermore, a 1% increase in human capital increases the level of output by 0.22% by directly increasing labour productivity. These panel estimates are close to the estimates of Rao and Vadlamannati for India with country specific time series data. Therefore, it can be said that their extension to the Solow model is useful in applied work. It would be interesting if some other alternative control variables are added by others to test the robustness of our results. But this is outside the scope of this paper.

Data Appendix

All variables are indexed and are 1 in 1960.

Real gross domestic product (Y). Source: Bosworth and Collins (2003), whose primary sources are *World Development Indicators* and *International Financial Statistics* (IMF).

Real stock of capital (K) is computed using the perpetual inventory method with an annual depreciation of 5%. Source: Bosworth and Collins (2003).

Human capital (H) is the average of number of years of schooling. Source: Bosworth and Collins (2003).

Labor Force (L) is from the *World Development Indicators* and Bosworth and Collins (2003).

GRAT is the ratio of government's current expenditure to GDP and TRAT is the ratio of the sum of exports and imports to GDP. Data are from the *United Nations* online database.

References

Bond, S., Hoeffler, A. and Temple, T., (2001) "GMM Estimation of Empirical Growth Models", unpublished.

Bosworth, B., and Collins, S. (2003) "The empirics of growth An update," *Brookings Papers on Economic Activity,* 22(1): 45–66.

Lucas, R. (1988) "On the mechanics of economic development," *Journal of Monetary Economics,* 22(1): 3-42.

Mankiw, N., Romer, D., and Weil, D. (1992) "A contribution to the empirics of economic growth," *Quarterly Journal of Economics,* 107 (2): 407-437.

Rao, B. B. and Vadlamannati, K.C. (2009) "The level and growth effects of human capital in India," *Applied Economics Letters*, forthcoming.

Rao, B. B. (2010) "Time Series Econometrics of Growth Models: A Guide for Applied Economists", *Applied Economics, 42* (1): 73–86.

Rao, B. B., and Singh, R. (2007) "Effects of trade openness on the steady state growth rates of selected Asian countries with an extended exogenous growth model. MPRA Paper 8605, University Library of Munich, Germany.

Solow, R., (1956) "A contribution to the theory of economic growth," *Quarterly Journal of Economics,* 71(1): 65-94.