Estimating the Permanent Growth Effects of Human Capital

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Abstract

This paper estimates with the least trimmed least squares (LTS) a specification suitable to estimate the permanent growth effects of human capital, using educational attainment (H) as a proxy. Our results show that H has significant permanent growth effects but these are much smaller than in Temple (1999).

Keywords: Least Trimmed Squares, Human capital, Educational attainment, Permanent growth effects.

JEL: O15; O40.

1. Introduction

The growth effects of human capital (HK), are controversial. In two influential contributions Benhabib and Spiegel (1994, BS) and Pritchett (1997) have found that HK has only weak or no growth effects. In another influential work Temple (1999) has argued that these weak effects are due to the outliers in the data set of BS. Therefore, he has reestimated the BS specification with a robust regression method viz., the least trimmed least squares (LTS) and found that the growth effects of HK, proxied with educational attainment (H) are positive and significant. However, in the specifications of BS, therefore in Temple, there is no distinction between the actual yearly growth effects and permanent or the steady state growth effects of H. This paper proposes an alternative method to estimate the permanent growth effects of H and estimates them with the BS data. The structure of this paper is as follows. Specification issues are discussed in Section 2 and empirical results are in Section 3. Section 4 concludes.

2. Specification

An important aspect of BS's seminal contribution is the use of the growth accounting framework to estimate the growth effects of H. Temple provides a succinct overview of BS's contribution. This can be explained with a simple H augmented Cobb-Douglas production function (CD) as follows.

$$Y = AK^{\alpha} L^{\beta} H^{\gamma} \tag{1}$$

where Y = real output, K = physical capital, L = labour and H = human capital proxied with educational attainment. Total differentiation of (1) gives the log-linear form:

$$\Delta \log Y = \Delta \log(A) + \alpha \Delta \log Y + \beta \Delta \log L + \gamma \Delta \log H \tag{2}$$

For pure cross section studies (2) can be expressed as:

$$\begin{aligned}(\log Y_T - \log Y_0) &= (\log A_T - \log A_0) + \alpha(\log K_T - \log K_0) \\ &\quad + \beta(\log L_T - \log L_0) + \gamma(\log H_T - \log H_0) \\ \dot{Y} &= constant + \alpha \dot{K} + \beta \dot{L} + \gamma \dot{H}\end{aligned} \tag{3}$$

where the T and 0 subscripts, respectively, are for the end period (1985) and initial period (1965) values of the variable. Dots on the variables represent log differences i.e., proportionate changes. According to BS and Temple the growth effects of H will be significant if γ is significant. BS's *OLS* estimates of γ range from 0.063 (t = 0.80) to -0.080 (t = -1.25) and all of their estimates of this parameter are insignificant. However, Temple used LTS to identify data outliers and deleted them step by step. His estimates of γ ranged from 0.111 (t = 1.66), with 6 deletions, to 0.164 (t = 4.00), with 14 deletions; see Table 1 in Temple. Thus Temple's LTS estimates of the growth effects of educational attainment are positive and significant.

Some limitations in these two influential works are as follows. Firstly, there is no distinction between the actual annual growth effects, which are likely to be transitory, and the steady state or permanent growth effects of H. While policy makers may be interested in both types of growth effects, they will be more interested in the steady state growth effects if the actual growth effects persist only for one period. Therefore, a distinction between these two growth effects is necessary. To estimate the permanent growth effects the CD production function is modified first as follows:

$$Y = A_0 e^{(a+bH)t} K^{\alpha} L^{\beta} H^{\gamma} \tag{4}$$

where $A_0 =$ initial stock of knowledge and $t =$ number of periods. In this formulation, as can be seen from the following derivation, H will have both permanent level and growth effects. To derive the permanent level and growth effects of H, we shall use the solution for the steady state level of per worker income of the Solow (1956) growth model from Mankiw, Romer and Weil (1992, MRW), which is:

$$y^* = A_0 e^{(a+bH)t} (s_k)^{[\alpha/(\beta-\gamma)]} (s_h)^{[\gamma/(\beta-\gamma)]} (n+g+\delta)^{-[(\alpha+\gamma)/(\beta-\gamma)]} \tag{5}$$

where $y^* =$ steady state level of per worker income, $s_k =$ investment ratio in physical capital, $s_h =$ investment ratio in human capital, $n =$ rate of growth of labour, $g =$ rate of growth of technical progress, $\delta =$rates of depreciation of physical and human capital, which are assumed to be the same by MRW. Thus the key factors that determine the level of per worker income in the steady state are the stock of knowledge which depends on the level of H and the two investment ratios s_k and s_h. In order to estimate the dynamics of income adjustment MRW have used the following simple partial adjustment scheme.

(6) $$\Delta \log y \ = \lambda(\log y^* - \log y)$$

where the term in the brackets measures the gap between the steady state and actual levels of income. Therefore, a low estimate of λ implies high persistence in the rate of growth of output. To estimate the dynamics of output adjustment and its transitory growth effects we need data on the two investment ratios s_k and s_h. However, the steady state rate of growth of y^* can be derived with the available data since the time derivative for equation (5), is:

(7) $$\Delta \log(y^*) = a + bH$$

where it is assumed by definition that in the steady state all other parameters, the two investment ratios and H are constant. Since the steady state rate of growth of output (SSGR) is an unobservable variable, it can be only derived by using the estimates of the production function in (4) or its variants. In this regard SSGR is similar to the natural rate of unemployment (NRU). Both are unobservable and they have to be derived by estimating an appropriate dynamic model and by imposing the steady state conditions such as in equation (7).

3. Empirical Results

Empirical results with BS's data are in Table 1. In regression (1) *OLS* estimates of equation (3) are reported. These are almost identical with those in BS. However, note that γ and β are both insignificant. In regression (2) the same is estimated with LTS as in Temple (1999). It is noteworthy that all the coefficients are now significant and close to Temple's estimates in regression (2) of his Table 1. However, while γ is significant only at the 10% level in Temple, it is significant at the 5%. The estimate of γ implies that a one percent increase in H increases the actual growth rate by 0.135 percent over a twenty year period. However, this growth effect will persist only for one period and will vanish in the steady state. Since the dynamics of growth cannot be estimated using pure cross section data with the partial adjustment specification in equation (6), it can be said that if H increases by one percent every year, the rate of growth of output will be 0.0067 percent every year. If this increase in H stops growth also stops.

To derive the permanent growth effect of H, we estimated the production function in equation (4) and the results are in regression (3) of Table 1. For the levels of the variables their values in 1985 are used and a dummy variable for the industrial countries *INDDUM* has been added.[1] As expected the coefficient of this dummy variable is positive and significant, implying that the stock of knowledge in the industrial countries is about 12% higher than in the developing countries. However, while the coefficients of capital and labour are significant at the 1% level, the coefficients of log H and H, although positive, are insignificant. Furthermore the coefficients of capital and labour add approximately to unity, implying that there are constant returns with respect to these inputs. Therefore, we have used the intensive form of equation (4) and its LTS estimate is in regression (4). There is hardly any change in the estimates and the coefficients of log (H) and H have remained insignificant. This could be due to the high correlation between these two variables of 0.95. To maintain the constant returns assumption, log(H) is dropped and the estimate is in regression (5). All the coefficients are significant now and the point estimate of log (K/L) is identical to Temple's estimate of the coefficient of $\Delta \log K$, implying that the share of profits is the same in both estimates; see regression (3) of Table 1 in Temple (1999). The coefficient of H is at 0.052 is significant at the 5% level and implies that the permanent growth effect of an additional year of education is about 5% over a twenty year period. In Temple an additional year of education implies 18% increase in H because the mean of H in 1985 is 5.5 years.

[1] When the 1965 or the averages of 1965 and 1985 values are used for the levels of the variables we obtained similar estimates. To classify countries into industrial and developing countries we used per worker incomes. Countries with less than $6,500 per worker are classified as developing countries. This tallies with the list of countries classified by the World Bank for concessional prices for its publications with a couple of minor exceptions.

Table 1

Regression	1	2	3	4	5
constant	0.268***	0.092	3.274***	3.284***	3.291***
	(2.79)	(1.24)	(7.47)	(7.26)	(6.71)
$\Delta \log K$	0.457***	0.553***			
	(7.9)	(7.4)			
$\Delta \log L$	0.208	0.286*			
	(1.02)	(1.77)			
$\Delta \log H$	0.063	0.135**			
	(0.92)	(2.02)			
INDDUM			0.400***	0.399***	0.401***
			(4.49)	(4.48)	(4.16)
$\log K_{85}$			0.529***	0.529***	0.535***
			(8.52)	(8.46)	(8.36)
$\log L_{85}$			0.472***		
			(6.92)		
$\log H_{85}$			0.190	0.188	
			(1.39)	(1.41)	
H_{85}			0.012	0.012	0.052**
			(0.30)	(0.31)	(2.04)

Notes: Heteroscedasticity-consistent t-ratios are reported in parentheses. *, ** and *** signify significance at 10%, 5% and 1% levels. $K =$ physical capital, $L =$ labour, $k = (K / L)$, $H =$ educational attainment. Sources of data are Benhabib and Spiegel (1994) and http://jontemple.blogs.ilrt.org/abstracts/growth/#educnote.

Therefore, the implied growth effect of H is 3% over 20 years, but these are not permanent growth effects.

4. Conclusions

This paper has used a specification and framework to estimate the unobservable permanent growth effects of educational attainment. Our estimates are significant and imply that an additional year of education permanently adds about 5% to the growth of output over a 20 year period. Our results imply that the weak or no effect found by BS seems to be due to the presence of outliers in the data, as found by Temple. Our estimates of this growth effect, however, is higher than in Temple but conceptually they differ since BS's growth accounting approach can only estimate the year on growth effects of H.

Needless to say there are some limitations in our paper. We did not estimate the dynamics of adjustment of output. As Temple has noted, panel data methods are likely to be more informative on these dynamics. To reduce multi-colinearity we have dropped log (H). Therefore, the coefficient of H is likely to be perhaps biased upwards.

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