An alternative interpretation of "average years of education" in growth regressions

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Abstract

The majority of the empirical literature uses average years of education as a proxy of the human capital stock. Based on Lucas (1988) we argue that the level of average years of education should be used as a proxy for the growth rate of the per capita human capital stock. This has fundamental impact on the interpretation of the coefficient and may explain some of the contradictory empirical results.

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1. Introduction

Since there are few reliable estimates of the human capital stock, and even these are limited in time and space, most empirical work on economic growth has to rely on some kind of human capital proxy, such as literacy rates, primary school enrolment, age-heaping, or average years of education. This latter is by far the most popular choice, partly because of the availability of large datasets by Kyriacou (1991), Nehru *et al.* (1995), Barro and Lee (1993, 2001), Cohen and Soto (2001), and de la Fuente and Doménech (2002).

In the most influential empirical studies (Benhabib and Spiegel, 1994; Krueger and Lindahl, 2001; Cohen and Soto, 2001; de La Fuente and Doménech, 2002), the stock of per capita human capital is proxied by average years of education. Benhabib and Spiegel (1994) test both the Lucas (1988) and Romer (1990) endogenous growth models on a sample of 29 countries observed for 1965 and 1985. They find that when the growth of the per capita income is regressed on both the growth of physical capital stock and the growth of the average years of education, the latter coefficient remains insignificant. In an alternative specification, however, the level of average years of education yields positive coefficients. The authors interpret this result as a confirmation of the Romerian growth theory: higher level of human capital stock leads to faster technological development and ultimately higher growth rates. Krueger and Lindahl (2001) arrive at a similar conclusion: when the growth of physical capital is included, only the level of the average years of education seems to yield significant and positive coefficients. Yet, generally it is assumed that the human capital coefficients should be significantly higher than found by empirical studies (Judson, 1996, 2002; Psacharopoulos, 1994, 2004).

The literature offers two kinds of explanations for these results. Possibly the most obvious candidate is the low quality of data. Indeed, average years of education seems to have been estimated with considerable error (Soto 2002; Portela *et al.*, 2004), which is further worsened by taking the first differences (Krueger and Lindahl, 2001; de La Fuente and Doménech, 2002). Soto also suggests that the multicollinearity between the log of capital stock and average years of education can be responsible for the unsatisfactory results.

The alternative explanation is theoretical: Pritchett (2001) argues that insignificant human capital coefficients may make sense: the low quality education in developing countries does not necessarily generate human capital, or, on the contrary, there is an permanent excess supply of human capital which reduces the returns from education. In both cases, however, education will be weakly correlated with economic growth.

In this paper we offer a third explanation, namely, that the average years of education coefficients are incorrectly interpreted. While empirical studies use the average years of education as a proxy for the level of human capital stock, in fact, it should rather be used as a proxy for the growth rate of human capital stock. As such, empirical results suggesting a link between average years of education and growth of per capita income are in complete accordance with the theory of Lucas, but by no means are confirmations of the theory of Romer.

In this paper we adopt the following structure: in Section 2 we briefly review the theory of Lucas, suggest a way to incorporate the average years of education in the growth regression, and derive the empirical model. In Section 3 we estimate the empirical specification on 21 OECD countries, for the period 1960-1995, and interpret the results. This is followed by the conclusion in Section 4.

2. The Lucas model

In the Lucas model (1988) there are two sectors. The first sector produces aggregate income (Y_t) using physical capital (K_t) and human capital (H_t), with the possibility of increasing returns to scale due to the positive external effect of human capital. The latter depends on the average human capital endowment of the economy (h_t).

$$Y_t = K_t^{\alpha}\left(u_t H_t\right)^{1-\alpha} h_t^{\gamma} \quad (1.)$$

The first sector employs a share ($0<u_t<1$) of the available human capital, the rest is devoted to the production of additional human capital in the second sector with constant returns to scale:

$$\dot{H} = \lambda(1-u_t)H \quad (2.)$$

where λ is a technical parameter assumed to be constant. Since the total human capital stock in the economy equals the product of the per capita human capital stock (h_t) and the population (L), (1.) can be expressed in per capita terms:

$$y_t = k_t^{\alpha} u_t^{1-\alpha} h_t^{1-\alpha+\gamma} \quad (3.)$$

where lowercase letters denote per capita values.

We can use (3.) to express the growth rate of the economy:

$$\frac{\dot{y}}{y} = \alpha\frac{\dot{k}}{k} + (1-\alpha)\frac{\dot{u}}{u} + (1-\alpha+\gamma)\frac{\dot{h}}{h} = \alpha\frac{\dot{k}}{k} + (1-\alpha)\frac{\dot{u}}{u} + (1-\alpha+\gamma)\lambda(1-u_t) \quad (4.)$$

The empirical literature usually neglects the fact that u_t may also change. If more resources are employed in the second sector ($1-u_t$ increases), the growth in the first sector should decrease *ceteris paribus*.

For an empirical application of (4.), the primary concern is to find a suitable proxy for the share of human capital employed in the second sector. It is reasonable to assume that ($1-u_t$) is roughly equal to the share of time allocated to education and learning. The explanation is that the average years of education reflects the average years of education followed by the representative agent for each year t. Dividing this by the life expectancy yields the share of the representative agent's life that is devoted to human capital formation by means of education. One may also argue that this share reflects the share of the population that is still being educated in a certain year. Under the assumption that life expectancy is constant, average years of education is an obvious proxy of ($1-u_t$):

$$1-u_t=\theta e_t \quad (5.)$$

where e_t denotes the average years of education in year t. Similarly, we can argue that $\frac{\dot{u}}{u}$ can be proxied by the change of the average years of education. Using (5.) we arrive at the following relationship:

$$\frac{\dot{u}}{u}=-\frac{\theta e_t}{1-\theta e_t}\frac{\dot{e}}{e} \quad (6.)$$

That is, the coefficient of the growth rate of the average years of education depends directly on e_t and changes over time. In order to capture this effect, one needs to allow this coefficient to vary over time in the regression.

As a result, the empirical version of (4.) is as follows:

$$\Delta \ln y_{i,t}=\alpha \Delta \ln k_{i,t}+\left[(1-\alpha+\gamma)\lambda\theta\right]\cdot e_{i,t}-\beta\left(\Delta \ln e_{i,t} t\right)+\eta_i+\varepsilon_{i,t} \quad (7.)$$

Where t, η_i and $\varepsilon_{i,t}$ denote a time trend, the country-specific unobserved effects, and the error-term, assumed to be i.i.d., respectively.[4] Equation (7.) states that the growth of per capita income depends both on the level and the growth rate of the average years of education. But while the first is expected to yield a positive coefficient, the latter should have a negative impact on economic growth. This is exactly what the majority of the literature finds but dismisses as an unexpected, odd result. In fact, however, these findings are in accordance with the Lucas model.

Also equation (7.) offers an explanation why the average years of education coefficients are usually found to be small. Since the average years of education is a proxy for the human capital formation, the coefficient contains the technical efficiency parameter of the second sector (λ) and the factor at which the average years of education is converted into 1-u_t (θ). Since the product of these is very likely to be less than unit, the coefficient is also significantly lower than the factor share of human capital.

A possible augmentation of (7.) is to include the squared average years of schooling in the regression, which enables us to test for the presence of non-linearities in the second sector. This latter is a crucial point in the Lucas theory, because endogenous growth may only exist if there are non-decreasing returns to scale in the production of human capital. This assumption has so far met some skepticism in the empirical literature (Monteils, 2002; Gong, Greiner, and Semmler, 2004).

3. Data and results

The data on GDP and physical capital stock are obtained from Kamps (2006), while we used the average years of education dataset of de la Fuente and Doménech (2002). The panel consists of 21 OECD countries and 8 years (1960, 1965, 1970, 1975, 1980, 1985, 1990, 1995). The results are reported in Table 1.

Table 1 about here

Specification 1 suggests that if one neglects non-linearities in the relationship between education and the formation of human capital, all education variables yield insignificant coefficients. The results form Specification 2 show that after capturing the non-linearity, all coefficients are significant and have the expected sign. If we take the unobserved country-specific effects into account (Specification 3 and 4), the coefficients are significant and of the right sign even without the e_t^2, even though this latter causes a significant improvement of the fit, and reduces the magnitude of the physical capital coefficient from the very high 0.5-0.6 to about 0.27, which is closer to what is generally found or assumed in the literature (Mankiw *et al.*, 1992; Bosworth *et al.*, 1995). The negative coefficient of the growth rate of average years of education indicates that any redistribution of the inputs from the first sector toward the second sector leads to an immediate (and possibly temporary) reduction in the growth of per capita income. Because in this specification, we have already captured the effect of increasing level of education on this coefficient, in absolute terms it should be quite near to the real factor share of human capital (roughly 0.3).

Another important finding is that the relationship between education (as a proxy of the input in the second sector) and human capital formation is not linear. The critique on this assumption of the Lucas model seems to be confirmed. The results suggests that while the educational attainment of the population is relatively low, education has an increasing return to human capital formation, after a threshold value is reached, at around 8 years of education, the second sector will experience decreasing returns to scale. This corresponds well with the results by Krueger and Lindahl (1991), who find increasing returns to about 7.5 years of education and decreasing returns afterwards.

4. Conclusion

In this paper, we suggested that following the theory of Lucas (1988) the average years of education should rather be used as a proxy for the share of resources devoted to human capital formation. As such, it is the level and not the growth of the average years of education that should positively affect economic growth. This has two further empirical consequences.

First, the growth rate of the average years of schooling serves as a proxy for the immediate effect of redistributing inputs from the first sector toward the second sector. As such, finding a negative effect of the growth of education on economic growth is not erroneous, but rather confirms the Lucas theory.

Second, the average years of education coefficient contains not only the factor share of human capital, but also the technical parameter of the human capital formation (λ_t) as well as the parameter θ that establishes link between the proxy (education) and the share of resources devoted to human capital formation ($1-u_t$).

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Footnotes

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[2] There is an alternative way to incorporate education in growth regressions as well. One may argue that the representative agent's human capital is increased by the additional education he or she takes but not by all education he or she had before. Hence, the growth of the human capital stock should be proxied by the growth of average years of education. This, however, means that the growth of average years of education in growth regressions should yield a positive and significant coefficient. Since empirics do not confirm this interpretation, our reasoning should be preferred.

[3] Because $\lim_{e_t \to \infty} -\frac{\theta e_t}{1-\theta e_t} = 1$, as e_t tends to infinity, the coefficient of $\frac{\dot{e}}{e}$ should equal (1-α). In practice, however, the average years of education are between 5 and 10 years. In these cases, the coefficient of the change of the average years of education will overestimate (1-α) by a factor of 1.25-1.11 respectively.

[4] If one assumes that the average years of education is constant in the long-run, the growth rate of the average years of education could be omitted from this specification. We still choose to go on with this specification, since we would like to arrive at an empirical specification identical to Krueger and Lindahl (2001).

Table 1.

Estimation results from the panel regression dependent variable: $\Delta lny_{i,t}$

(N=21, T=8, number of observations= 140)

	Spec 1	*Spec 2*	*Spec 3*	*Spec 4*
$\Delta lnk_{i,t}$	0.871^{a}	0.618^{a}	0.522^{a}	0.273^{c}
	(11.70)	(9.22)	(4.67)	(1.97)
$e_{i,t}$	0.0101	0.0304^{a}	0.0100^{a}	0.0612^{a}
	(0.91)	(4.12)	(5.10)	(3.54)
$e_{i,t}^{2}$	-	-0.0021^{a}	-	-0.0038^{a}
		(-3.77)		(-3.00)
$\Delta lne_{i,t} \cdot t$	0.022	-0.105^{c}	-0.287^{a}	-0.305^{a}
	(0.54)	(-1.91)	(-3.31)	(-3.89)
R^2	0.867	0.879	0.895	0.903
Country-dummies	No	No	Yes	Yes

The superscripts a, b, and c denote significance at 1, 5 and 10% respectively. Heteroscedasticity and serial correlation robust t-statistics are reported in parentheses.