INCREASES IN HUMAN CAPITAL AND GROWTH: NEW DATA, MORE CONCLUSIVE RESULTS.

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Increases in Human Capital and Growth: New Data, More Conclusive Results

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Abstract

Using a new data set for human capital/adult, I show that changes in human capital cause economic growth in 56 countries over the 1985 to 2005 period. I show that these results are superior to results using average schooling attainment.

I. Introduction

There is little question that increases in a nation's human capital cause growth. Hundreds of micro studies consistently show a positive relationship between a worker's level of schooling and earnings [Psacharopoulos and Patrinos, 2004]. Micro studies also generally find that education has positive external effects on workers' income and on societal well-being [Hanushek and Woessmann, 2008].

In contrast, most macro studies have not found evidence that increases in schooling cause economic growth. Krueger and Lindahl [2001] investigated this enigma and determined that measurement error in the schooling data combined with fixed effects techniques that difference the data over short periods caused severe attenuation bias in the estimates in many of these studies. They concluded that the failure to control for the endogeneity of schooling also biased the estimates.

Subsequently, Cohen and Soto [2007] revised the existing average schooling attainment data for 95 countries and then estimated the effect of schooling on national income over the 1960-90 period. They were unable to obtain reasonable estimates using country-specific fixed effects. But using GMM estimation with lagged schooling variables for instruments, they obtained evidence that across countries schooling causes economic growth. Morrisson and Murtin [2009] have since further refined the schooling attainment data for some of these countries.

These improvements in the national schooling attainment data have reduced the reporting error in these data, but they have not addressed a more fundamental measurement error. Even when correctly reported, average schooling attainment is an inaccurate measure of human capital because it does not account for differences in the composition and the quality of schooling.

Countries with more schooling at higher levels are likely to have invested more per year of schooling because higher levels of schooling are more costly [Breton, 2010]. In addition, even if two countries have similar average levels and distributions of schooling, one may have invested more per year of schooling. Economists refer to this condition as a difference in the quality of schooling [Barro and Lee, 1996].

In this paper I examine the effect of changes in human capital on growth over the 1985 to 2005 period using a new measure of human capital that accounts for differences in schooling quality. This measure is the net human capital stock, created from a nation's cumulative investment in the schooling of its population of working age. Using this measure I find that changes in human capital cause economic growth and that the estimated effect is larger and more statistically-significant than the estimated effect of changes in average schooling attainment.

II. Human Capital Data

I calculate the human capital stock using the perpetual inventory method and four components of national investment in schooling: public expenditures, private expenditures, the cost of capital during schooling, and foregone student earnings. I use a working life of 40 years and a linear depreciation rate of 2.5% per year. I calculate the stock in year t using the investment made between years t-45 and t-5. The methodology is thoroughly documented in Breton [2012a]. The key component is annual public expenditures in education, which I calculate using UNESCO data for the annual share of GDP invested in education and annual GDP data from Penn World Table 6.3 [Heston, Summers, and Aten, 2009].

In this study I use estimates of the human capital stock for 56 countries in 1985, 1990, 1995, 2000, and 2005. I selected the 56 countries because they were all market economies over the 1950-2005 period, they had available UNESCO data for 1950-2000, and they had data on

average schooling attainment from Morrisson and Murtin [2009] or Cohen and Soto [2007] for 1980-2010. I used Morrisson and Murtin's data for 46 countries and Cohen and Soto's data for the remaining 10 countries in 1990 and 2000. I estimated average attainment in 1985, 1995, and 2005 using their data for 1980, 1990, 2000, and 2010.

Figure 1 shows the two sets of data in 2000. The data are representative of a wide range of countries. The two data sets are highly correlated ($\rho = 0.90$ in 2000), but they also exhibit considerable variation. For example, the adult populations of working age in Syria, Colombia, and Portugal in 2000 all had about seven years of schooling, but the estimates of human capital/adult are about $5,000 in Syria, $13,000 in Colombia, and $36,000 in Portugal (2005 US $).

Differences in these two sets of data over time are much less correlated. The differences in the data between 1985 and 2005 have a correlation coefficient of only 0.34.

GDP/adult is highly correlated with both measures of human capital, but the correlation is higher with the data created from cumulative investment. Figure 2 shows the relationships between log(GDP/adult) and log(human capital/adult) and between log(GDP/adult) and average schooling attainment in 2000. The correlation coefficients are 0.95 and 0.87.

Figure 1
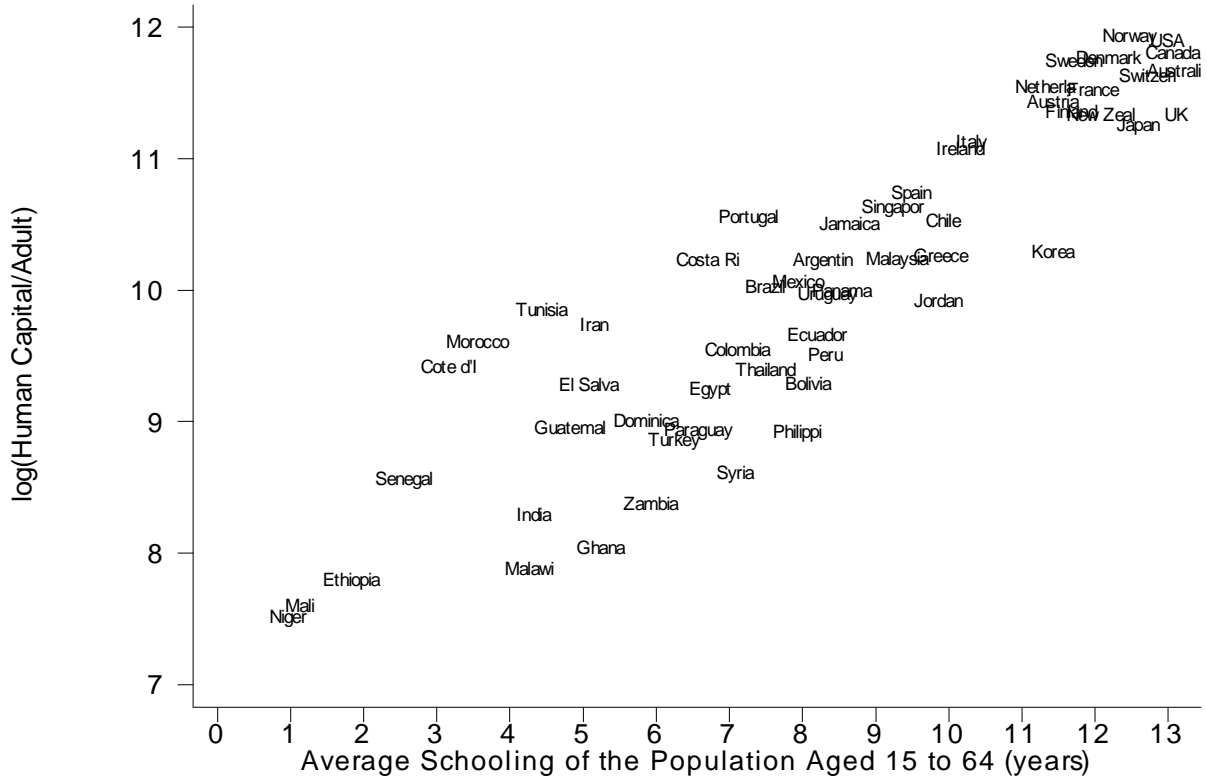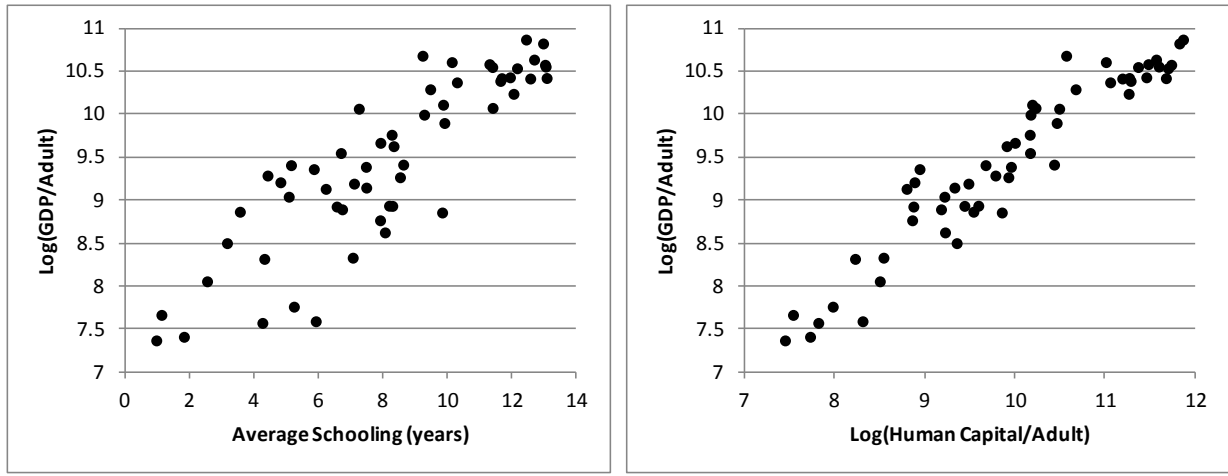**Log(Human Capital/Adult) vs. Average Schooling Attainment in 2000**

Figure 2
GDP/Adult vs. Average Schooling Attainment and vs. Human Capital/Adult in 2000

III. National Income Model

I use the standard augmented Solow model to compare the effects of the two human capital data sets [Mankiw, Romer, and Weil, 1992]:

(1) $\quad (Y/L)_{it} = (K/L)_{it}{}^{\alpha} (H/L)_{it}{}^{\beta} A_t{}^{(1-\alpha-\beta)}$

In this model Y is national income, K is the physical capital stock, H is the human capital stock, L is the number of adults, and A is a common trend in world total factor productivity.

Given the high correlation between the stocks of physical capital and human capital and the greater measurement error in the measures of human capital, estimates of the income model in equation (1) tend to produce estimates of α that are biased upward and estimates of β that are biased downward. Less biased estimates of the effect of different measures of human capital are typically obtained using a reduced form of the model in which Y/L is a function of the capital/output ratios:

(2) $\quad (Y/L)_{it} = (K/Y)_{it}{}^{\alpha/(1-\alpha-\beta)} (H/Y)_{it}{}^{\beta/(1-\alpha-\beta)} A_t$

As shown in Figure 1, the relationship between human capital/adult and average schooling attainment is log-linear, so I use this relationship in the estimates:

(3) $\quad \beta \log(H/L) = \gamma \text{ attainment}$

Taking the log of equation (1) and its various reduced forms and substituting the relationship in equation (3) into these models yields the following models:

(4) $\quad \log (Y/L)_{it} = A_0{}_{(1-\alpha-\beta)} gt + \alpha \log (K/L)_{it} + \beta \log(H/L)_{it} + \varepsilon_{it}$

(5) $\quad \log (Y/L)_{it} = A_0 gt + (\alpha/1-\alpha-\beta) \log(K/Y)_{it} + \beta/(1-\alpha-\beta) \log(H/Y)_{it} + \varepsilon_{it}$

(6) $\quad \log (Y/L)_{it} = A_0{}_{(1-\alpha-\beta)} gt + \alpha \log (K/L)_{it} + \gamma \text{ Attainment}_{it} + \varepsilon_{it}$

(7) $\quad \log (Y/L)_{it} = A_0{}_{(1-\alpha-\beta/1-\alpha)} gt + (\alpha/1-\alpha) \log(K/Y)_{it} + (\gamma/1-\alpha) \text{ Attainment}_{it} + \varepsilon_{it}$

I estimated these models using data for GDP/adult and physical capital/adult calculated

from data in Penn World Table 6.3. I calculated GDP/adult from the rgdpch and the rgdpeqa

data sets. I calculated physical capital/adult using the perpetual inventory method, the ci share of

GDP invested, GDP/adult, a geometric depreciation rate of 0.06, and data for the 25 years prior

to year t. I used PWT 6.3 rather than PWT 7.0 because the PWT 6.3 data appear to be more

reliable [Breton, 2012b].

All of the models are estimated using 2SLS and the log of the Protestant share of the

population in 1970 as an instrument to control for endogeneity and attenuation bias. The

Protestant share data are from Barrett [1982]. Breton [2012a] uses this instrument for human

capital/adult and for average schooling attainment and provides extensive documentation to

support its validity.

IV. Model Results

Table 1 presents the results for the various models. Columns 1 to 4 present the results

using average schooling attainment. Columns 5 to 8 present the results with human capital/adult.

In all cases the estimates using the new human capital data are superior to the results using the

schooling attainment data.

In a Solow model α is physical capital's share of national income, which on average is

about 0.35 across countries [Bernanke and Gurkaynak, 2001]. All of the model results using

schooling attainment yielded an implied value for α that is too high, ranging from 0.46 to 0.61.

The best results provide values of $\alpha = 0.46$ and $\gamma = 0.07$. These results are similar to Cohen and

Soto's results for 1960-1990, which were $\alpha = 0.40$ and $\gamma = 0.08$.

In contrast, the results using the human capital stock data yielded acceptable implied

values of α for three of the four models, ranging from 0.33 to 0.41, and higher estimates of the

effect of schooling. These estimates are all statistically-significant at the one percent level. The results using country-specific fixed effects (column 6) have implied values of α = 0.33 and β = 0.41. These estimates are very similar to Breton's [2012a] estimates across countries in 1990 (α = 0.34 and β = 0.36), which he showed are consistent with micro estimates of the effect of schooling on income in workers' earnings studies.

Table 1								
National Income/Adult vs. Schooling Attainment and Human Capital/Adult **(Dependent Variable is Log(GDP/Adult))**								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Countries	56	56	56	48	56	56	56	48	48
Sample	280	280	280	240	280	280	280	240	240
Technique**		FE		X-sSA		FE		X-sSA	X-sSA
Log(K/Adult)	0.61*	0.53*			0.54*	0.33*			
	(.03)	(.05)			(.05)	(.08)			
Log(K/Y)			0.95*	0.86*			1.24*	1.04*	0.95*
			(.10)	(.08)			(.07)	(.11)	(.10)
Log(H/Adult)					0.14*	0.41*			
					(.06)	(.06)			
Log(H/Y)							0.76*	0.97*	0.50*
							(.16)	(.14)	(.18)
Attainment	0.03	.05	0.11*	0.13*					0.07
	(.01)	(.03)	(.02)	(.01)					(.03)
Year	0.006*	0.005*	0.010*	0.008	0.005	-0.001	0.009	0.004	0.006
	(.002)	(.002)	(.004)	(.003)	(.002)	(.001)	(.005)	(.005)	(.004)
R^2	.96	.99	.80	.79	.97	.99	.68	.55	.72
Implied α	.61	.53	.49	.46	.54	.33	.41	.35	.39
Implied β					.14	.41	.25	.32	.21
Implied γ	.03	.04	.05	.07					.03

Note: White-adjusted standard errors in parentheses
*Statistically significant at the 1% level.
**All estimates use 2SLS.

Column 9 confirms the superiority of the human capital stock relative to average years of schooling as a measure of a nation's level of human capital. When both measures are included in the income model, the coefficient on the human capital stock variable explains more of the

variation in income and is more statistically significant than the coefficient on the schooling attainment variable.

V. Conclusions

The empirical results in this study provide evidence that increases in human capital cause economic growth and that the augmented Solow model is a valid model of the growth process. The results also indicate that the quality of schooling (i.e., the amount of resources expended) is important in determining the magnitude of the effect that increased schooling has on the rate of growth.

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