Do cognitive skills Impact Growth or Levels of GDP per Capita?

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Abstract

The Great Recession has raised concerns about future economic growth. A possible remedy that was suggested was an educational reform, which will increase the stock of high skilled workers. In this paper we test if such a reform has a level or a growth rate effect. Focusing on this question, we construct a variant standard growth model in which human capital has theoretically both a level and growth rate effects by assumption. Estimating this model using standard cross-country data and panel data, human capital measured by the methodology of Hanushek and Woessmann (2015) has a significant level effect on GDP per worker but not a growth effect. Therefore, the human capital improvement impact on economic growth is bounded.

JEL Clasification: I25, O47, O15, I20

Keywords: Education and Economic Development, Empirical Studies of Economic Growth, Human Capital, Secular Stagnation

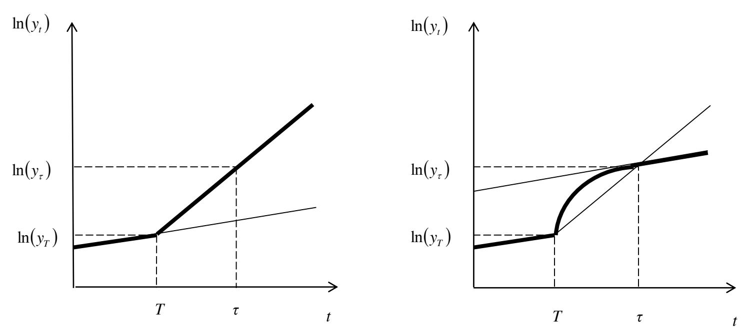
1 Introduction

Since the Great Recession the United States and other advanced and developing economies have experienced a substantial slowdown in the growth rate of GDP per capita. With historically low interest rates and an increasing debt to GDP ratio, a need for other policy tools was raised. Some scholars argue that an educational reform may improve the actual long run growth rate of the economy. The question at stake is whether such a reform will affect the level of GDP per capita or the long-run growth rate. This is the question we study in this paper.

The Great Recession and the slow recovery that many economies in the world have been experiencing raised the possibility that these economies suffer from the so-called phenomenon of Secular Stagnation.

According to this phenomenon, the long-run growth rate of the economy has declined, perhaps because low-skilled workers have dropped out from the labor force steadily since the 1980's (See for example, Chapter 5 in Baldwin and Teulings (2014)).[1] A possible solution to the problem is to improve the educational system in the US, since such a reform will increase the stock of high-skilled labor at the expense of low-skilled labor. Note that such a reform will not affect the potential long-run growth rate of GDP per capita, but rather its level. On the other hand, some studies (Hanushek and Woessmann, 2015, HW) have argued that such a reform will affect the long-run growth rate of GDP per capita, because a more skilled labor force is capable to absorb and invent new technologies more easily.

Needless to say, the policy implications of such different possible outcomes is substantial, as Figure 1 illustrates. Let us consider the following exercise, similar to the one presented in HW: Suppose that a country is on its steady state growth path. At period T the economy experiences an educational reform that increases its average human capital level, and hence output per capita grows at a higher rate for a certain period (between period T and τ). If investment in human capital has a growth effect, this economy will experience this high growth rate for all future periods, as the left part of the figure shows. If, on the other hand, investment in human capital has a level effect (as implied in Baldwin and Teulings (2014)), then the spike in the growth rate is temporary; it will decline eventually to its original rate of growth, and the impact of such a reform on output per capita will be substantially lower, as shown in the right part of the figure.



a. A growth rate effect caused by an educational reform at time *t*.

b. A level effect cause by an educational reform at time *t*.

Figure 1: A growth rate effect (left) and a level effect (right) of an educational reform

To answer this question of growth vs. level effect, we use a neoclassical growth model presented in Mankiw et al. (1992). In the model, investment in human capital has a level effect by assumption.

[1]Some scholars (e.g., **?**) argue that the advanced economies experience several headwinds, such as the end of the educational revolution, which has an upper bound. Consequently, the *potential* growth rate declines as well.

We estimate our model using data from Penn World Tables (Feenstra et al., 2013, PWT), and measure human capital with data from HW, which relies on the quality of schools rather than on the quantity of schooling. Our first specification replicates the main specification of HW, and indeed, our results are very similar to theirs. Yet since in our case this specification springs from a model in which human capital has a level effect by assumption, we argue that such a specification cannot identify a growth effect and refute the interpretation of a level effect.

In our second specification we add to the model other components that according to growth theory and the model may have an impact on output per worker in the long run, such as the average growth rate of population and the average investment rate in physical capital. As a result, the coefficient of the investment in human capital declines, suggesting that not only does the impact of investment in human capital may have a level effect, but also that it is smaller than the results of HW once we partial out the effect of investment in physical capital and the impact of the population growth rate.

Finally, we show that the coefficient of investment in human capital is statistically significant only when initial output per worker is one of the regressors, suggesting that the positive effect is significant *conditional* on the initial output per capita level. This is consistent with the conditional convergence hypothesis, according to which investment in human capital has a level effect. We conclude from this result, and from the fact that in this model human capital has a level affect by assumption, that investment in human capital has a level effect, as part of the conditional convergence hypothesis.

As a robustness check, we extend the model and allow investment in human capital to have a growth effect. In this model, each country converges to a globally stable steady state. Yet, unlike our basic model, in this model, even in the steady state countries may differ in their growth rates, since the growth rate of each economy depends on its level of human capital. We estimate this model, and show that the model does not fit the data, suggesting that the data do not support the growth effect hypothesis.

So far, our analysis relied on cross country data. Yet as argued above, such an approach cannot fully distinguish between a level and a growth effect. A more powerful approach is to use panel data, because such data follow an economy for a long period of time, and hence they enable a better identification of the level and growth effects. Furthermore, panel data allow to account for country specific fixed effects, and this way to disentangle the potential bias caused by some omitted variables that are country specific.

We follow the methodology of HW in constructing the measure of human capital based on the average achievement of students in international tests in Math and Sciences. The only difference between our measure and theirs is that they use an average of all scores in all tests, whereas we construct a panel of these scores. Since only thirteen countries participated in these test for a long enough period, we restrict our sample for these countries. The construction of the level of human capital over time reveals that none of the countries has experienced a sharp increase in the average achievements of its students in the international tests. These findings raise two questions: First, whether the level of human capital is bounded from above, and as such so is its impact on the level of GDP per worker;[2] Second, whether the countries in the sample that experienced a higher growth rate of human capital indeed experienced a higher growth rate of GDP per capita as well.

In order to answer these questions, we execute a growth accounting exercise *á la* Benhabib and Spiegel (1994). We assume a standard production function, in which the level of human capital affects separately the level of output per worker and the rate of technical change. Hence, the model includes both the level effect *and* the growth effect. We develop from the production function the growth rate of output per worker, which in turn depends on both the level of human capital and its growth rate, capturing both the growth effect and the level effect, respectively.

We estimate the model described above, using data from PWT and our calculations of human capital. Since most of the international tests are taken at the age of 14, we use in our estimations a five year lag of the cognitive skills level. As mentioned above, if cognitive skills have a growth effect, then their *level* should be positively correlated with the growth of GDP per capita, while if they have a level effect then their *change* should be correlated with the growth rate of GDP per capita.

We first measure the model assuming that human capital has a growth effect alone. The coefficient of the level of human capital on GDP per worker growth rate is not statistically significant. We then test the hypothesis of the level effect alone (assuming that there is no growth effect of human capital on growth), and indeed the coefficient of the change in human capital is positive and statistically significant.

Finally, we do not restrict the model, and allow both level effect and growth effect play a role. Consistent with our previous results, the level of human capital is not correlated with the growth rate of output per worker, whereas the change in the level of human capital (which captures the level effect) is positive and statistically significant. We conclude from this analysis that consistent with the cross country analysis, the panel data support the level effect hypothesis, rather than the growth effect hypothesis.

We take the analysis one step forward, and attempt to estimate separately the impact of the level of human capital on absorbing and inventing new technologies. In order to do so, we assume that beside the direct effect that the level of human capital has on growth, its interaction with the distance from

[2]This question is equivalent for the question of an upper bound in other human capital measures, as in Gordon (2014).

the technological frontier affects the growth rate of output per worker. This assumptions attempts to capture the ability to absorb new technologies: For a given distance from the frontier, the higher the human capital level, the faster the economy grows. Yet our estimation does not generate a positive and statistically significant coefficients for such an interaction. We conclude from this estimation that the data do not support the hypothesis that the level of human capital accelerates the rate of inventing or absorbing new technologies.

So how different is the impact of an educational reform if we interpret the impact as a level effect and not a growth rate effect? To answer this question, we repeat the simulations of HW, and take their simulations as a benchmark for a growth rate effect. HW argue that 90 years after an educational reform, output per capita will be 26% higher than its no-reform counterpart, our estimations suggest that after 90 years, output per capita will exceed its no-reform level by about 4.76%. Furthermore, the difference between the results of HW and ours increases over time. These results call for a new consideration of the educational reforms throughout the world.

2 A Baseline Model

In this section we use the model presented first in Mankiw et al. (1992, MRW). This is a simple neoclassical growth model in which human capital has a level effect by assumption. In the model, the accumulation of physical capital and human capital is determined endogenously, while the rate of technical change is exogenously given. Consider a closed economy, in which the production function of a single homogenous good is of the form:

$$Y_{i,t} = K_{i,t}^{\alpha} h_{i,t}^{\beta} \left(A_{i,t} L_{i,t}\right)^{1-\alpha-\beta} \tag{1}$$

where $Y_{i,t}$ is the output at period t in country i, $A_{i,t}$ is the (labor augmenting) technology level in country i at period t, $K_{i,t}$ is the capital employed in production in country i at period t, $h_{i,t}$ is the average level of human capital of a worker in country i at period t and $L_{i,t}$ is the raw labor employed in production in country i at period t; $0 < \alpha, \beta, \alpha + \beta < 1$. Output per effective labor is given by:

$$\tilde{y}_{i,t} = \tilde{k}_{i,t}^{\alpha} \tilde{h}_{i,t}^{\beta}, \tag{2}$$

where $\tilde{x}_{i,t} \equiv \frac{X_{i,t}}{A_{i,t} L_{i,t}}$.

2.1 The Dynamics of the Model

We assume that the technological parameter, $A_{i,t}$, increases in an exogenously given constant rate, λ.[3] We also assume that the population grows at a constant rate, n_i. The physical capital formation follows a usual law of motion, which implies that the change in the stock of physical capital equals the investment in physical capital, net of capital dilution:

$$\dot{\tilde{k}}_{i,t} = s_{K_i}\tilde{k}_{i,t}^{\alpha}\tilde{h}_{i,t}^{\beta} - (n_i + \lambda + \delta)\tilde{k}_{i,t}, \tag{3}$$

where δ is the depreciation rate, s_{K_i} is the investment rate in physical capital in country i, all assumed to be constant over time. Human capital evolves according to the following equation:

$$\dot{\tilde{h}}_{i,t} = s_{H_i}\tilde{k}_{i,t}^{\alpha}\tilde{h}_{i,t}^{\beta} - (n_i + \lambda + \delta)h_{i,t}, \tag{4}$$

where s_{H_i} is the investment rate in human capital.

2.2 Steady State and Deviations from the Steady State

A steady state in this economy is a state in which output per effective worker is constant over time. It is straightforward that the economy converges to a unique (non-trivial) steady state in which output per worker grows at a constant rate, λ.[4] Furthermore, physical capital per effective worker and human capital per effective worker are given respectively by:

$$\tilde{k}_i^* = \left(\frac{s_{K_i}^{1-\beta}s_{H_i}^{\beta}}{n_i + \lambda + \delta}\right)^{\frac{1}{1-\alpha-\beta}} \tag{5}$$

and

$$\tilde{h}_i^* = \left(\frac{s_{K_i}^{\alpha}s_{H_i}^{1-\alpha}}{n_i + \lambda + \delta}\right)^{\frac{1}{1-\alpha-\beta}}. \tag{6}$$

Finally, in the steady state, output per effective worker (in logarithmic terms) is given by:

$$\ln(\tilde{y}_i^*) = \frac{\alpha}{1-\alpha-\beta}\ln(s_{K_i}) + \frac{\beta}{1-\alpha-\beta}\ln(s_{H_i}) - \frac{\alpha+\beta}{1-\alpha-\beta}(n_i + \lambda + \delta). \tag{7}$$

[3] As discussed above, we relax this assumption below.

[4] See MRW for a detailed proof.

Log linearizing around the steady state yields the following equation:

$$
\begin{aligned}
\ln \tilde{y}_{i,t} - \ln \tilde{y}_{i,0} = & \left(1 - e^{-\gamma t}\right) \frac{\alpha}{1-\alpha-\beta} \ln s_{K_i} + \left(1 - e^{-\gamma t}\right) \frac{\beta}{1-\alpha-\beta} \ln s_{H_i} \\
& - \left(1 - e^{-\gamma t}\right) \frac{\alpha+\beta}{1-\alpha-\beta} \ln(n_i + \lambda + \delta) - \left(1 - e^{-\gamma t}\right) \ln(\tilde{y}_{i,0}),
\end{aligned} \tag{8}
$$

where $\gamma \equiv (1-\alpha-\beta)(n+\lambda+\delta)$ is the convergence rate of output per effective labor to its steady state.

One may be tempted to conclude from this specification that the investment rate in human capital affects the long-run growth rate of output per worker. This is, in fact, the interpretation in HW. However, this interpretation is not consistent with the model described above. To see this, note that in the steady state the economy grows at a constant rate, λ, which is independent of the human capital level. This is, in fact, the only element in a neoclassical model that has a growth effect, whereas all other economic variables, including human capital, have a level effect.

2.3 The Estimated Equation

In order to develop our estimated equation, note that $\ln y_t = \ln \tilde{y}_t + \ln A_0 + \lambda t$. Using this expression, we estimate the following equation:

$$
\begin{aligned}
\ln y_{i,t} - \ln y_{i,0} = & \lambda t + \left(1 - e^{-\gamma t}\right) \frac{\alpha}{1-\alpha-\beta} \ln s_{K_i} + \left(1 - e^{-\gamma t}\right) \frac{\beta}{1-\alpha-\beta} \ln s_{H_i} \\
& - \left(1 - e^{-\gamma t}\right) \frac{\alpha+\beta}{1-\alpha-\beta} \ln(n_i + \lambda + \delta) - \left(1 - e^{-\gamma t}\right) \ln(y_{i,0}) + \epsilon_i,
\end{aligned} \tag{9}
$$

where ϵ_i is a random residual. We estimate equation (9), under the assumptions that the exogenous growth rate of technology, λ, is common to all countries; we also assume, as in MRW that $A_{i,0}$ is common to all countries.[5]

HW estimate a similar equation, but they exclude the impact of investment in physical capital as well as the impact of population growth rate on output per capita growth rate. This specification is vulnerable to identification problems, as omitted variables may affect both growth and human capital accumulation. To overcome these problems, Hanushek and Woessmann (2012) implement an instrumental variable approach: They use institutional characteristics of the school system (such as the percentage of private schools, the existence of external exit exam systems etc.) and show that their results are not affected by these instruments. HW also argue that the problem of reverse causality is absent in their

[5] Islam (1995) showed that this assumption can be relaxed in a panel data analysis without affecting the results.

study, as they show that if they focus on tests that took place before the period studied, the coefficient of the level of cognitive skills increases, rather than declines, as one would expect if the problem of reverse causality existed in the data.

3 Data

We use data on GDP per capita and population size from 1960 to 2010 for 51 countries from Penn World Tables version 8.1 (Feenstra et al., 2013, PWT). All these countries did not belong previously to the Soviet bloc. We calculate the real GDP (on aggregate level) for these countries in these years, and then use data on the number of workers in these years from PWT as well to calculate output per worker in each year in the period 1960-2010, and its growth rate. We use data also from PWT to compute the average investment rate in physical capital for this period by calculating the investment as a percentage of GDP. We assume that the exogenous growth rate of technology is 2% (as in MRW), and that the depreciation rate is 4% (as suggested in the PWT (Inklaar and Timmer, 2013)). We also compute for each country its average annual growth rate of the labor force, n_i. Finally, we use the measure of cognitive skills from HW as our human capital measure, as it was shown previously that its correlation with growth is much more consistent than other measures of human capital. Table B.5 summarizes the statistics of the variables we use for our estimations. All variables except the human capital measure level are in percentage points.

4 Results

Table 1 presents the results of estimating equation (9). Column (1) includes only initial output per worker as a control variable. This regression is identical to the one reported in HW, and our results are very similar to the ones reported in their study. In their estimation, the coefficient of human capital is close to 2, and the coefficient of initial output per capita is close to -0.3.[6] However, HW argue that their results capture a growth effect, whereas our estimation springs from a model in which investment in human capital has merely a level effect. This by itself raises a concern whether such a specification indeed identifies a growth effect which is independent of a level effect. Furthermore, note that both in our estimation and in their estimation, the coefficient of initial output per worker is negative, supporting the conditional convergence hypothesis, according to which economies with similar characteristics converge

[6] The quantitative difference between our results and theirs springs from the fact that we use output per worker, whereas they use output per capita.

to the same steady state.[7] This theory supports the hypothesis that investment in human capital has a level effect.

Column (2) includes in addition the average investment rate in physical capital and the average population rate as independent variables. Their coefficients are positive and negative, respectively, exactly like the theory suggests. Note that once these variables are taken into account, the coefficient of investment in human capital declines from 1.39 to 0.81, reducing further the impact of investment in human capital on economic growth. This suggests also that the coefficients reported in HW include also the complementarity between investment in physical capital and investment in human capital, and the interaction between population growth and investment in human capital.

As described above, the negative coefficient of initial output per worker supports the conditional convergence hypothesis. According to this hypothesis, investment in human capital has a level effect, and not a growth effect. To rule out the level effect hypothesis, the coefficient of the human capital level should be positive and statistically significant even if initial conditions are not controlled for. This is the regression analyzed in column (3). Interestingly, the coefficient of the human capital measure ceases to be statistically significant. This is consistent with the conditional convergence hypothesis, according to which investment in human capital has merely a level effect, and not a growth effect.

Table 1: Growth and Investment in Human capital and Physical Capital

	Output per Worker Growth, 1960-2007		
	(1)	(2)	(3)
Cognitive Skills level	1.39***	0.81***	0.44
	(0.26)	(0.24)	(0.30)
Output per Worker, 1960	-0.66***	-0.70***	
	(0.15)	(0.12)	
$n + \lambda + \delta$		-0.44***	-0.23
		(0.15)	(0.18)
Investment Rate		0.09***	0.09***
		(0.02)	(0.02)
Adjusted-R^2	0.39	0.61	0.35
Observations	51	51	51

Notes: Standard error estimates are reported in parentheses; All regressions include a constant; *** denotes statistical significance at the 1% level, ** at the 5% level, and * at the 10% level, all for two-sided hypothesis tests.

[7] For more details on conditional convergence see, for example, Barro and Sala-i Martin (1992) and Durlauf et al. (2005).

5 Growth and Level Impact of Education

Our previous results rely on a model in which human capital has a level effect by assumption, and we argued that having a good identification of a growth vs. level effect is challenging with cross section data. Yet there are several reasons to think why human capital may have a growth effect, as a higher level of human capital may increase the ability of a society to invent and absorb new technologies.[8] These channels imply that the rate of technical change may depend on the level of human capital. As a first attempt to identify a growth effect, this is the assumption we make in this section:

$$g_{A_{i,t}} = \frac{A_{i,t+1}}{A_{i,t}} - 1 = \sqrt{h_{i,t}}. \tag{10}$$

This assumption, which suggests that the higher the average level of human capital, the higher the technical change, is consistent with the endogenous growth literature (e.g., Ha and Howitt (2007)),[9] and is similar to the assumption in Benhabib and Spiegel (1994). The rest of our model does not change. It turns out that in the steady state, output per worker equals:

$$\ln y_{i,t} = \frac{\alpha}{1-\alpha-\beta} \ln s_{K_i} + \frac{\beta}{1-\alpha-\beta} \ln s_{H_i} - \frac{\alpha+\beta}{1-\alpha-\beta} \ln[n_i + \lambda(h_i^*) + \delta] + \ln A_{i,t}, \tag{11}$$

where, as in the previous section, h_i^* is the steady state level of human capital. It is straightforward that since in the steady state the level of human capital is constant, so is the growth rate of technology. As a result, the term in the squared brackets is constant. This implies that in the steady state output per worker grows at a constant rate, $\sqrt{h_i^*}$. The *level* of human capital, on the other hand, may differ from one country to the other, as the investment rate in human capital may differ between countries. As a result, the *level* of human capital, may yield different growth rates in different countries. To test this specification, we take logs from both sides of (11) and subtract from both sides $\log y_{i,0}$. Finally, we subtract and add to the right hand side of (11) $\log A_{i,0}$. This yields the following equation:

$$\begin{aligned} \ln y_{i,t} - \ln y_{i,0} = {} & \frac{\alpha}{1-\alpha-\beta} \ln s_{K_i} + \frac{\beta}{1-\alpha-\beta} \ln s_{H_i} - \frac{\alpha+\beta}{1-\alpha-\beta} \ln(n_i + \lambda(h_i^*) + \delta) \\ & + \ln A_{i,t} - \ln A_{i,0} - \ln y_{i,0} + \ln A_{i,0}. \end{aligned} \tag{12}$$

[8] Another channel would be of positive externalities. Nevertheless, the evidence for such externalities are mixed. Acemoglu and Angrist (2001), for instance, find very weak evidence for such externalities.

[9] Note that the endogenous growth theory does *not* rule out convergence. See, for instance, Howitt (2000).

Note that along the steady state, the technological level grows at a constant rate, which is a function of the steady state level of human capital. Close to the steady state, the technological level grows also from the accumulation of human capital. As a result, in (12), $\ln A^*_{i,t} - \ln A_{i,0} \cong \sqrt{h^*_i} + \sqrt{\Delta h_{i,0}}$, where $\Delta h_{i,0} \equiv h^*_i - h^i_0$. Hence, the growth effect of the level of human capital is captured in two elements of this equation. First, in the expression in the squared brackets, $n_i + \sqrt{h^*_i} + \delta$, and second, in the expression of convergence toward the steady state, $\sqrt{h^*_i} + \sqrt{\Delta h_{i,0}}$.

In order to estimate this last equation, we assume that $\ln A_{i,0} = \ln \overline{A}_0 + \epsilon_i$, where $\ln \overline{A}_0$ is the average level of $\ln A_{i,0}$. Consequently, (12) can be written as:

$$\ln y_{i,t} - \ln y_{i,0} = \frac{\alpha}{1-\alpha-\beta} \ln s_{K_i} + \frac{\beta}{1-\alpha-\beta} \ln s_{H_i} - \frac{\alpha+\beta}{1-\alpha-\beta} \ln(n_i + \lambda(h^*_i) + \delta) + \sqrt{h^{i*}} + \sqrt{\Delta h^i_0} - \ln y_{i,0} + \ln \overline{A}_0 + \epsilon_i. \quad (13)$$

Estimating Δh^i_0

The measure of human capital developed by HW is calculated as an average scores of each country in the international tests it had participated in. Unfortunately, only 13 countries participated in these tests long enough to allow us to investigate its dynamics. In order to overcome this problem, we calculate the difference in the level of human capital under different assumptions regarding the average schooling years, as reported in Barro and Lee (2013). First, for each country we estimate $\Delta h_{i,0}$ by the difference in average schooling years. Second, we extrapolate the results in the international tests by using the growth rate of the average schooling years.

5.1 Results

Table 2 summarizes the results from estimating these two specifications. Columns (1) and (2) present the results of the estimations with our first and second specifications, respectively. As in the previous section, the average investment rate in physical capital is positive and close to 0.08; The coefficient of the initial level of output per worker in 1960 is negative, significant and close to its level in the Section 4. The coefficient of the level of human capital is positive and significant and close to its level in the previous section, but recall that this impact is the *level* effect we found in the previous section, and not the *growth* effect we attempt to estimate here.

The coefficients at stake are the coefficient of $n_i + \lambda(h^*_i) + \delta$ and the coefficient of the change in human capital. The first coefficient is negative and statistically significant. Interestingly, its magnitude is similar to the one obtained in Section 4. This raises the question whether the level of human capital indeed has an impact on the growth rate. In order to test this question we run two more regressions, reported in columns (3) and (4), where we omit $\lambda(h_i^*)$ from the expression $n_i + \lambda(h_i^*) + \delta$. Comparing the coefficients of $n_i + \delta$ in columns (3) and (4) to the ones of $n_i + \lambda(h^*) + \delta$ in columns (1) and (2) respectively, reveals that these coefficients are identical. This suggests that $\lambda(h)$ is a constant. If this is the case, then regressions do not provide any evidence that human capital indeed have a growth effect.

Finally, in none of the estimations reported, the effect of human capital on the growth rate of TFP (the coefficient of the change in human capital) is statistically significant. We conclude from all these results that despite the limitation in having a full identification of a growth effect in a cross section analysis, we find no evidence in the data for the assumption that the level of human capital has a growth effect.

Table 2: Output per Worker Growth in a Model of Endogenous Growth

	Output per Worker Growth, 1960-2007			
	A Model with $n + \lambda(h) + \delta$		A Model with $n + \delta$ alone	
	(1)	(2)	(3)	(4)
Investment Rate	0.08***	0.08***	0.08***	0.08***
	(0.02)	(0.02)	(0.02)	(0.02)
$n + \lambda(h) + \delta$	-0.45***	-0.45***		
	(0.16)	(0.16)		
Human Capital Level	0.86***	0.83***	0.75***	0.72**
	(0.26)	(0.27)	(0.28)	(0.29)
y_{1960}	-0.69***	-0.66***	-0.69***	-0.66***
	(0.13)	(0.14)	(0.13)	(0.14)
HC change, first spec	0.26		0.26	
	(0.41)		(0.41)	
HC change, second spec		0.37		0.37
		(0.52)		(0.52)
$n + \delta$			-0.45***	-0.45***
			(0.16)	(0.16)
Adjusted-R^2	0.59	0.59	0.59	0.59
Observations	49	49	49	49

Notes: Standard error estimates are reported in parentheses; All regressions include a constant; *** denotes statistical significance at the 1% level, ** at the 5% level, and * at the 10% level, all for two-sided hypothesis tests.

6 Panel Data Analysis

In sections 4 - 5 we argued, using cross country data, that the data support the hypothesis that investment in human capital has a level effect rather than a growth effect. Yet we also argued that cross section analysis is not the best fit for an identification of this kind. Panel data follow a sample of countries over time and therefore they provide a better basis for testing the level vs. growth effect of human capital. Furthermore, panel data allow us to account for time invariant country specific fixed effects, and this way to disentangle the potential bias caused by some omitted variables that are country specific.

6.1 Specification

Consider, once again, a production function in country i as given in (1). In this case, output per worker is given by:

$$\ln y_{i,t} = \alpha \ln k_{i,t} + \beta \ln h_{i,t} + (1-\alpha-\beta) \ln A_t. \tag{14}$$

Assume also, as in Section 5 that the growth rate depends on the level of human capital:

$$g_{A_{i,t}} = \phi + \chi \cdot h_{i,t}, \tag{15}$$

where $g_{A_{i,t}}$ is the growth rate of TFP in country i at period t, which depends on two elements: an exogenous element, denoted by ϕ, and the level of human capital in country i. We assume that the relation between the level of human capital and the growth rate of TFP is linear and captured by χ. This equation is a reduced form of both justifications for interpreting the results of a specification presented in (9) as a growth effect, namely that a higher level of human capital implies a higher level of both inventing and absorbing new technologies (We below attempt to estimate the two effects separately.).

Fully differentiating with respect to time yields the following equation:

$$g_{y_{i,t}} = \alpha g_{k_{i,t}} + \beta g_{h_{i,t}} + (1-\alpha-\beta) g_A(h_{i,t}) = \alpha g_{k_{i,t}} + \beta g_{h_{i,t}} + (1-\alpha-\beta)(\phi + \chi \cdot h_{i,t}),$$

where $g_{y_{i,t}}$ is the growth rate of GDP per worker in country i; $g_{k_{i,t}}$ is the growth rate of the capital stock per worker in country i; and $g_{h_{i,t}}$ is the growth rate of human capital in country i. Note that $\chi \cdot h_t^i$ represents the growth rate effect of human capital, and $g_{h_{i,t}}$ represents the level effect. Hence, the panel data provide us a simple specification to assess if human capital has a level effect or a growth effect, without assuming any assumptions of the laws of motion of each factor of production as well as on the state of the economy. In this section, then, we estimate the following equation:

$$g_{y_{i,t}} = \alpha g_{k_{i,t}} + \beta g_{h_{i,t}} + (1-\alpha-\beta)(\phi + \chi \cdot h_{i,t}) + \Delta_i + \epsilon_{i,t}, \tag{16}$$

where Δ_i is country time-invariant fixed effects and $\epsilon_{i,t}$ is an error term. If human capital has a growth effect, one would find a positive and statistically significant estimator of χ, whereas if human capital has a level effect, one would find a positive and statistically significant estimator of β. Note that most previous studies, which used panel data, attempted to estimate a neoclassical growth model and its convergence rate. As such, they used the level of output per worker as the dependent variable (e.g., Islam (1995)). We, on the other hand, try to identify the growth and level effects. Consequently, we use the growth rate of output per worker as our dependent variable.

6.2 Data

In the panel data analysis, we do not assume that the countries are in their steady state, nor do we assume any laws of motion on any state variables. As a result, the data we use differ from the ones we used in the cross section analysis. In order to estimate (16), we use direct measures of the stocks of physical capital per worker rather than its average annual change within the entire period examined in the cross section.

We use data from PWT on the real capital and labor stocks, and real output for the countries in our sample for the period 1970-2005.[10] For each country, we calculate the annual level of output per worker. We then divide the entire period of 1970-2005 to 5 year long sub-periods. We calculate for each sub-period the average annual growth rate of output per worker and of the stock of capital per worker. This approach, as well as the length of the sub-periods is very common in the literature (e.g., Islam (1995)).[11]

In order to construct a measure of human capital, similar to the one used in the cross section analysis, we follow the methodology of HW. This measure is based on the average student achievements in international tests in math and sciences. This restricts us to focus on the thirteen countries, which have participated in these tests long enough. The international tests were initiated in 1964, and since then they took place several times a decade. Table 3 presents the thirteen countries that participated either

[10] We restrict our analysis until 2005 in order to avoid some biases that may emerge due to the Great Recession.

[11] For a thorough survey of the literature using panel data in growth regressions, see Section VI.ii Durlauf et al. (2005).

in the first tests in 1964, or in the second ones in 1970 and hence construct our sample. The table shows that these countries participated in at least five different tests (the average among these countries is 7.07). Note that all these countries are advanced, suggesting that we cannot analyze in this section different growth patterns of developed and developing countries that may arise, for example, due to threshold externalities (e.g., Azariadis and Drazen (1990)).

Table 3: Countries with Early Participation in International Tests
& Average Years of Schooling, 1970, 1990

Country	Year of First Participation	No. of Times Participated	Avg. Years of Schooling, 1970	Avg. Years of Schooling, 1990
Australia	1964	8	11.44	11.97
Belgium	1964	7	9.5	11.57
United Kingdom	1964	9	8.48	9.05
Finland	1964	7	8.66	10.15
France	1964	6	7.41	10.03
Germany	1964	5	4.2	11.35
Israel	1964	5	10.39	12.31
Italy	1970	6	7.38	10.74
Japan	1964	9	10.72	12.41
Netherlands	1964	8	9.1	11.43
New Zealand	1970	7	13.13	12.55
Sweden	1964	6	9.9	12.16
United States	1964	9	12.53	12.89

We use the methodology developed by HW to construct a measure of human capital. Yet unlike HW, we construct for each country a series of this measure.[12] For each of these countries, we calculate the measure for each year the country participated in the international tests. Since most countries did not participate in all the tests that took place, and since the tests did not take place in all the years in our sample, we linearly interpolate the results for these missing years. Figure 2 presents the human capital measure in these countries over time. For most of the countries that participated in 1964, there is a sharp rise in the measure of human capital between 1964 and 1970. However, after 1970 the dynamics are mixed: some countries experience a moderate increase (e.g. Australia); some experience a relative decline (e.g., Israel) and other countries do not have a specific trend (e.g., Sweden and Belgium). Note also that the measure of human capital has not risen sharply for none of these countries. This raises the question whether an increase in human capital much above the range presented in the figure is feasible. Furthermore, it is not clear whether those countries which experienced some increase in their human capital indeed experienced a higher growth than those which did not experience such an increase in the

[12]See Hanushek and Woessmann (2012) for a detailed explanation of the methodology.

stock of human capital.

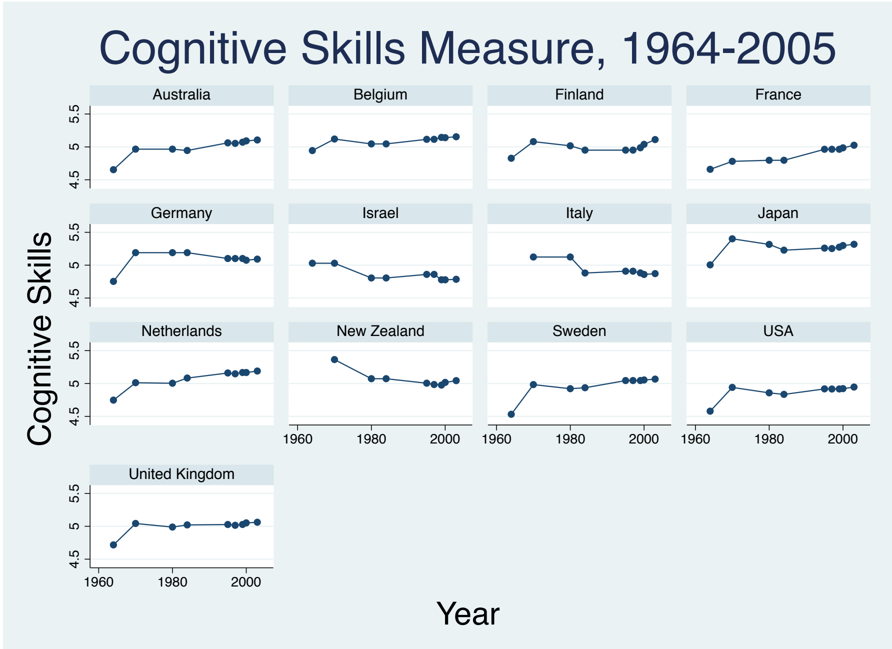


Figure 2: The measure of cognitive skills for countries which participated in international tests since 1964 or 1970

The international tests are taken at the ages of 10, 14 and 17. Most of the exams are for the ages of 14 (45%) and 17 (31%).[13] Since we attempt to capture how variations in the test scores affected long run growth, we use the cognitive skills measure with a lag of 5 years, which means that the individuals who took the exams 5 years earlier are 15, 19 and 22 years old, respectively.

Table 3 explains why we use a five year lag. For the countries in our sample, the table provides the average years of schooling of the 20-24 year old cohort in 1970 and 1990, as well as the share of this cohort that graduated high school and college (in percentage points). As can be seen in the table, the average schooling years in 1970 for the cohort of 20-24 year olds was 9.5. This suggests that on average, individuals entered the labor force around the age of 17. This means, that students who participated in the international tests when they were 14 entered the labor force on average 3 years later. The same methodology reveals that in 1990 the average schooling years of the 20-24 year old cohort was 11.43, suggesting that on average students who took the test when they were 14, entered the labor force 5 years later. Note that a five year lag for all exams that had taken place at the age of 17, implies that the vast majority of the population is already in the labor force.[14]

[13] Most of the exams for 10 year old students took place towards the end of the 1990's and as such they form a small part in our sample.

[14] As described above, exams for the 10 year old were not so prevalent during most of the period we analyze. Consequently, we emphasize more on individuals who took the exams when they were either 14 or 17.

6.3 Results

Our estimated model is a model with country fixed effects, as the Hausman test rejects the random effects model. Table 4 presents our results for estimating (16) using the data described above. In the first column we test whether there is a growth rate effect, without any controls (that is, assuming that β and α equal zero). The coefficient of the level of human capital is negative and marginally statistically significant. In column (2) we add the change of physical capital, yet the coefficient of the level of human capital is still negative and not statistically significant. In column (3) we test whether human capital has a level effect, without any controls (that is, assuming that χ and α equal zero). The coefficient is positive and statistically significant at the 5% level. In column (4) we add the controls of the change in stock of capital per worker. The coefficient of the change in human capital increases in magnitude (from 1.2 to 1.3), and is statistically significant at the 1%. Finally, in columns (5) and (6) we include as independent variables both the change in the human capital and its level, and only the change in human capital is statistically significant at the 10% 5% respectively. In column (6) we add to the analysis back the change in the capital and labor stocks, and none of the coefficients of the level of human capital is significant. We conclude from this table that the data supports the level effect hypothesis rather than the growth rate effect.

Table 4: Growth Rate vs. Level Effect Analysis

	Annual GDP per Worker Growth					
	Growth Effect Alone		Level Effect Alone		Both Effects	
	(1)	(2)	(3)	(4)	(5)	(6)
HC Level (5 year lag)	-0.04*	-0.03			-0.02	-0.01
	(0.02)	(0.02)			(0.02)	(0.02)
HC Growth (5 year lag)			1.20**	1.30***	0.95*	1.15**
			(0.42)	(0.42)	(0.45)	(0.43)
Capital Growth		0.08**		0.10***		0.10**
		(0.04)		(0.03)		(0.03)
Adjusted-R^2	0.05	0.10	0.07	0.16	0.08	0.16
Observations	104	104	104	104	104	104

Notes: Both levels and changes in cognitive skills are calculated with a 5 year lag. Standard error estimates clustered at the level of the country fixed effects are reported in parentheses; *** denotes statistical significance at the 1% level, ** at the 5% level, and * at the 10% level, all for two-sided hypothesis tests; All regressions include a constat.

Robustness One concern with our results are that these are driven by the lag that we chose. Tables 4, A.2 and A.3 in Appendix C provide evidence that this is not the case. These tables provide the results of estimating (16) with lags of 3, 6 and 10 years for our measure of cognitive skills (and their change), respectively. As can be seen, the level of cognitive skills (χ) is never positive and statistically significant. In fact in Table A.2 it is *negative* and statistically significant at the 5%. The change in the cognitive skills measure is always positive, and statistically significant either at the 1% or the 5% when the lag we use is either 3 or 6 years. It is not statistically significant when we use a 10 year lag. This, however, may be due to the decline in the sample of 13 observations that happens due to the large lag we impose in this table.

Another potential concern with a fixed effects model in panel data may arise due to the relatively small number of observations in each country. In such a case, since the between variation is not used for estimating the coefficients, the standard errors of the coefficients may be large.[15] In order to overcome this problem, we estimate a random effects model. Its results are presented in Table A.4. As can be seen in the table, not only are our result unaffected by the random effect model, but also their significance is higher.

6.4 Absorbing vs. Inventing New Technologies

As we argued above, theory provides two explanations for finding a growth effect: a more skilled labor force can invent and absorb new technologies more easily. Hence, one can think of the level of human capital as having two distinct effects on the growth rate of the economy. First, human capital has a direct effect on the growth rate, as it affects the rate of technical change in the economy. Second, it has an effect through the ability to absorb new technologies. The rate of the latter depends also on the distance from the technological frontier. In this subsection we attempt to identify these two different channels.

Consider the production function of output per worker presented in (14). Unlike the previous subsection, we now assume, in the spirit of Benhabib and Spiegel (1994), that the level of human capital affects the growth rate of TFP in two different ways: First, it has a direct effect due to inventing new technologies. Second, it accelerates the pace of catching up with technologies from the technological frontier. Hence, for a given distance from the frontier, a higher human capital stock implies a higher growth rate of TFP. These two channels can be summarized by the following equation:

$$g_{A_{i,t}} = \phi + h_{i,t}\left[\chi + \frac{\max A_t - A_{i,t}}{A_{i,t}}\right], \tag{17}$$

[15] For a deep discussion of this problem, see Section VI.ii in Durlauf et al. (2005).

where $\max A_t$ is the highest level of TFP observed in time t in the sample of countries. Hence, for a given level of human capital stock, the further the economy is from the frontier, the faster it can grow (as the technologies to be implemented are easier), and for a given distance from the frontier, the higher the human capital level, the faster the growth of the technology. Applying this equation to (16) yields the following specification:

$$g_{y_{i,t}} = \alpha g_{k_{i,t}} + \beta g_{h_{i,t}} + (1-\alpha-\beta)\left[\phi + h_{i,t}\left(\chi + \frac{\max A_t - A_{i,t}}{A_{i,t}}\right)\right] + \Delta_i + \epsilon_{i,t}. \tag{18}$$

6.5 Results

Table 5 presents the results of estimating (18). In column (1)-(3) we estimate how the interaction of the level of human capital and the distance from the technological frontier affects the growth rate of the economy. Interestingly, the coefficient is not significant, neither statistically nor economically. Furthermore, in column (2) we add the change in the stock of physical capital per worker and in column (3) we add the change in the stock of human capital. Both are statistically significant, and have the expected positive coefficient with a similar magnitude to the one obtained Table 4.

Columns (4)-(6) are similar to columns (1)-(3) respectively, only in the former we add also the direct effect of human capital on the rate of inventing new technologies. This coefficient is negative in all regressions, and marginally statistically significant in one column. Moreover, as before, the coefficient of the change in the stock of physical capital per worker (in columns (5) and (6)) and of the change in the stock of human capital (column (6)) are statistically significant, positive and with similar magnitude of the previous estimations. Hence, we find no evidence that human capital has an effect on the growth rate of neither inventing nor absorbing new technologies.

7 Discussion

In this section highlight the quantitative differences between our results, namely that human capital has a level effect, and other results, which suggest that human capital investment has a growth rate effect, for which we use the simulation presented in HW. Figure 3 represents the impact of an educational reform with the two interpretations. The horizontal axis represents time from the beginning of the educational reform, while the vertical axis represents the ratio of GDP per capita after the reform, relative to a scenario of no reform, in which we assume that the economy grows at a constant rate of 1.5%.

Table 5: Role of CS in Inventing vs. Absorbing New Technologies

	Annual GDP per Capita Growth					
	Absorbing Technology			Absorbing and Inventing		
	(1)	(2)	(3)	(4)	(5)	(6)
HC Level (5 year lag)				-0.04*	-0.03	-0.01
				(0.02)	(0.02)	(0.02)
HC Growth (5 year lag)			1.33***			1.18**
			(0.43)			(0.44)
Dist*HC	0.00	-0.00	-0.00	0.00	-0.00	-0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Capital Growth		0.10**	0.11***		0.09**	0.10**
		(0.04)	(0.03)		(0.04)	(0.03)
Adjusted-R^2	-0.01	0.07	0.15	0.04	0.10	0.15
Observations	104	104	104	104	104	104

Notes: Both levels and changes in cognitive skills are calculated with a 6 year lag. Standard error estimates clustered at the level of the country fixed effects are reported in parentheses; *** denotes statistical significance at the 1% level, ** at the 5% level, and * at the 10% level, all for two-sided hypothesis tests; All regressions include a constant.

We follow HW and assume that the reform has four stages:[16] In the first stage, the educational reform initiates, and the students' quality of human capital increases gradually, until the reform is fully enacted, after 20 years. Only then students begin to enjoy the highest quality of human capital. During the second stage, which lasts also 20 years, students – who, due to the first stage of the reform, have slightly higher quality than present workers – replace the workers in the labor force. In the third stage, new workers replace the old workers who were the first to enjoy the educational reform, and as such, do not have the highest possible quality of human capital (recall that it took the reform twenty years to be enacted fully). Finally, after twenty years of the third stage, the economy reaches the fourth stage of the reform, in which all the labor force has the high human capital quality.

As a benchmark, we use the results of HW, who interpret the impact of an educational reform as a growth rate effect; their estimation is depicted by the upper curve. Our simulation is based on the results above in Table 1, and they differ from the simulation of the results of HW in two aspects. First, the coefficient of the impact of such a reform on the change in the (short-run) growth rate is 0.89, rather than 2, as used by HW. Second, unlike HW, we assume that the growth rate of GDP per capita converges towards 1.5%. Furthermore, we assume that the convergence rate is 2%, as we calculate the convergence rate from 1.[17] This convergence rate is similar to the one reported in Barro and Sala-i Martin (1992) and

[16] For more information, see Chapter 7 in HW.

[17] Since the convergence rate is given by $\gamma = (n + \lambda + \delta)(1 - \alpha - \beta)$, we can compute the convergence rate from the results in the Table 1.

Mankiw et al. (1992).

In order to distinguish between the effects of the two differences between the the growth effect interpretation and the level effect interpretation, we add another simulation, which uses the coefficients of HW, but experiences convergence back the to previous steady state growth rate of 1.5%. Hence, this simulation does not partial out the effects of physical capital accumulation and population growth rate on human capital accumulation.

At the first stage of the reform, there are no big differences between the three simulations. However, as the second stage of the reform initiates, differences between the three simulations emerge, and the growth rate simulation curve becomes steeper than the two level effect simulations. Note that as the years go by, while the simulation of HW becomes steeper, the other two become flatter. This is due to the forces of convergence, which are absent in the case of a growth rate effect. Finally, HW calculate that 90 years after the reform, output per capita will be higher than its level without such a reform by about 26%. Our simulations do not support this viewpoint; they imply a much more moderate impact: after 90 years from the educational reform output per capita is only 4.76% higher than its level without a reform. Furthermore, the "level effect only" simulation predicts also a minor effect on output per capita 90 years of the reform of slightly over 10%.

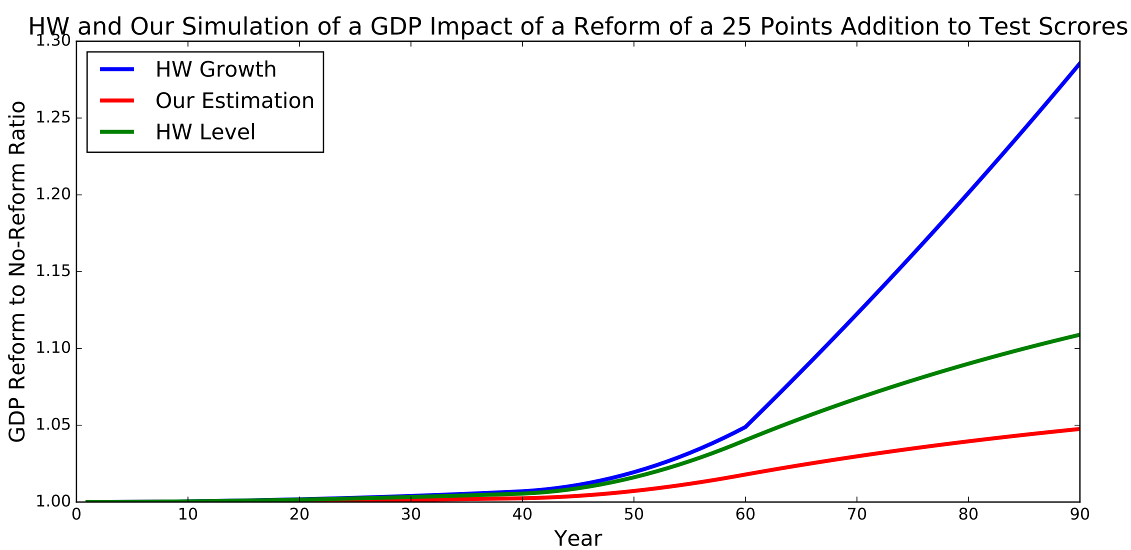


Figure 3: The ratio between GDP per capita after reform and without reform for our results and previous results.

8 Conclusions

The recent macroeconomic developments in the last decade have raised a concern on the future growth of different economies in the world, perhaps due to secular stagnation. A potential remedy, it was argued, is to invest in an educational reform, which will provide a more skilled labor force. This study asks whether such a reform has a growth effect or a level effect. In order to answer this question, we use a simple neoclassical growth model, in which human capital only has a level effect by assumption. We estimate our baseline model using data from PWT and HW, and show that the model supports the level effect hypothesis. Furthermore, we show that the data do not fit an extended model in which we assume that the level of human capital has a growth effect.

We also use panel data based on 13 OECD countries to answer this question. The data reveal that the level of human capital among these countries had mixed dynamics, and in all of the countries the level of human capital is close to a certain level (of 5). This raises the question whether the level of human capital (as measured in terms of quality rather than quantity) is bounded from above.

Using the panel data, we test a model that incorporates both the level and the growth effects. We show that the data support only the level effect, and not the growth effect. Furthermore, we show that the data do not support neither one of the theoretical justifications of a growth effect of absorbing or inventing new technologies. We conclude from this analysis that there is no evidence that the quality of human capital affects the long run growth rate of output per worker. As a result, we show quantitatively that the impact of human capital on output per worker is much smaller that under the assumption that it has a growth effect.

This study raises several questions for future research that have some policy implications. First, it highlights the possibility that human capital is bounded from above. If this is the case, policies that attempt to raise the average level of human capital by increasing the level of all the students might overshoot their target. Instead, it may be better to target education policies to reduce the dispersion of students' achievements in the international tests. This may increase the average cognitive skills – and hence stimulate economic prosperity – by helping more the less abled students. This is also consistent with some of the causes raised of the decline in the participation rate of unskilled workers in the labor force.

Second, this paper, as well as HW, emphasizes the role of cognitive skills in promoting economic prosperity. However, empirical evidence also suggest that high test scores result also from non-cognitive skills such as ambition, motivation and adequate personality traits.[18] While exploring the impact of these non-cognitive skills on economic development is beyond the scope of this study, we find it important for understanding the role of education in the process of development.

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Appendix

A Robustness Checks for the Panel Data Analysis

Table A.1: Growth Rate vs. Level Effect Analysis Using a 3 Year Lag

	Annual GDP per Worker Growth					
	Growth Effect Alone		Level Effect Alone		Both Effects	
	(1)	(2)	(3)	(4)	(5)	(6)
HC level (3 year lag)	-0.03	-0.02			-0.00	0.00
	(0.03)	(0.03)			(0.03)	(0.03)
HC Growth (3 year lag)			1.85***	1.76***	1.80**	1.77**
			(0.59)	(0.54)	(0.75)	(0.71)
Capital Growth		0.09**		0.09**		0.09**
		(0.04)		(0.03)		(0.03)
Adjusted-R^2	0.02	0.08	0.11	0.17	0.10	0.17
Observations	104	104	104	104	104	104

Notes: Both levels and changes in cognitive skills are calculated with a 5 year lag. Standard error estimates clustered at the level of the country fixed effects are reported in parentheses; *** denotes statistical significance at the 1% level, ** at the 5% level, and * at the 10% level, all for two-sided hypothesis tests; All regressions include a constat.

Table A.2: Growth Rate vs. Level Effect Analysis

	Annual GDP per Worker Growth					
	Growth Effect Alone		Level Effect Alone		Both Effects	
	(1)	(2)	(3)	(4)	(5)	(6)
HC Level (6 year lag)	-0.04**	-0.03*			-0.02	-0.01
	(0.01)	(0.02)			(0.01)	(0.01)
HC Growth (6 year lag)			1.18**	1.25***	0.83*	1.02**
			(0.40)	(0.41)	(0.41)	(0.39)
Capital Growth		0.09**		0.10***		0.10**
		(0.03)		(0.03)		(0.03)
Adjusted-R^2	0.06	0.12	0.07	0.16	0.08	0.16
Observations	104	104	104	104	104	104

Notes: Both levels and changes in cognitive skills are calculated with a 5 year lag. Standard error estimates clustered at the level of the country fixed effects are reported in parentheses; *** denotes statistical significance at the 1% level, ** at the 5% level, and * at the 10% level, all for two-sided hypothesis tests; All regressions include a constat.

Table A.3: Growth Rate vs. Level Effect Analysis

	Annual GDP per Worker Growth					
	Growth Effect Alone		Level Effect Alone		Both Effects	
	(1)	(2)	(3)	(4)	(5)	(6)
HC Level (10 year lag)	-0.01	-0.02			-0.02	-0.02
	(0.01)	(0.01)			(0.01)	(0.01)
HC Growth (10 year lag)			-0.15	0.28	-0.30	0.13
			(0.32)	(0.37)	(0.36)	(0.40)
Capital Growth		0.07**		0.07*		0.07**
		(0.03)		(0.03)		(0.03)
Adjusted-R^2	-0.00	0.04	-0.01	0.03	-0.01	0.03
Observations	91	91	91	91	91	91

Notes: Both levels and changes in cognitive skills are calculated with a 5 year lag. Standard error estimates clustered at the level of the country fixed effects are reported in parentheses; *** denotes statistical significance at the 1% level, ** at the 5% level, and * at the 10% level, all for two-sided hypothesis tests; All regressions include a constat.

B Summary Statistics

B.1 Variables Used in the Cross Section Analysis

Table A.4: Growth Rate vs. Level Effect Analysis: Random Effects Model

	Annual GDP per Worker Growth					
	Growth Effect Alone		Level Effect Alone		Both Effects	
	(1)	(2)	(3)	(4)	(5)	(6)
HC Level (5 year lag)	-0.01	-0.01			0.00	0.00
	(0.01)	(0.01)			(0.01)	(0.01)
HC Growth (5 year lag)			1.23***	1.32***	1.24***	1.36***
			(0.45)	(0.45)	(0.45)	(0.43)
Capital Growth		0.09**		0.10***		0.10***
		(0.04)		(0.03)		(0.04)
Adjusted-R^2						
Observations	104	104	104	104	104	104

Notes: Both levels and changes in cognitive skills are calculated with a 5 year lag. Standard error estimates clustered at the level of the country fixed effects are reported in parentheses; *** denotes statistical significance at the 1% level, ** at the 5% level, and * at the 10% level, all for two-sided hypothesis tests; All regressions include a constat.

Table B.5: Summary statistics

Variable	**Mean**	**Std. Dev.**	**Min.**	**Max.**	**N**
Output per Worker Growth Rate, 1960-2007	2.321	1.247	-0.721	5.165	51
Cognitive Skills Level	4.523	0.594	3.089	5.338	51
Initial Output per Worker, 1960	1.624	1.184	0.074	4.189	51
$n + \lambda + \delta$	7.694	0.967	6.338	10.262	51
Investment Rate	24.997	6.728	3.784	39.401	51