Measuring Human Capital Using Labor Market Data: An Application to the Study of Cross-Country Economic Growth (A Policy-Paper Version)

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Abstract

In this paper, we propose a novel estimate for human capital and use it in estimating cross-country production functions in a panel-data setting. We then compare our results with the ones previously obtained to emphasize the neglected importance that human capital has received so far in this context. Here, human capital is the expected present-discounted value of future labor income. We show how this can be easily implemented in empirical exercises, despite the fact that labor income is a non-stationary integrated process.

Our human capital proxy has two interesting characteristics: first, it captures the well-known trend observed on the number of years of schooling, present in every country. Second, its cross-sectional variation (across countries) is much grater than that observed for the number of years of schooling, which we credit to the fact that it captures cross-country differences in the quality of human capital. Indeed, the coefficient of variation (unit free) of our proxy of human capital is 3 times that of years of schooling for OCDE countries, and more than 7 times when the Penn World Tables data base is used. As a consequence, its use implies an increased human-capital elasticity in the production function vis-a-vis that obtained using years of schooling,

and a more prominent role of human capital in growth accounting exercises.

Sumário Executivo:

Nesse artigo propomos uma nova forma de medir o capital humano, i.e., o conhecimento individual acumulado com potencial produtivo, e o usamos para revisitar a questão da importância do capital humano para o crescimento econômico num contexto de estimativas de funções de produção agregadas com dados de um painel de países.

Seguindo alguns artigos da literatura de finanças, e.g., Lettau e Ludvigson (2001, Journal of Finance), definimos o estoque de capital humano como o valor presente esperado do fluxo de renda de trabalho num contexto de horizonte infinito. Ao contrário da literatura de finanças, propomos aqui uma forma econométrica de operacionalizar estimativas do capital humano. Primeiramente, nossa proposta contorna o problema da não estacionariedade da renda do trabalho no cômputo do seu valor presente esperado. Nesse caso, usamos as técnicas propostas no conhecido artigo de Beveridge e Nelson (1981, Journal of Monetary Economics). A partir daí, sob algumas hipóteses baseadas em resultados empíricos, mostramos que se pode escrever o capital humano como uma função linear da renda do trabalho corrente e de suas primeiras diferenças no período corrente, numa representação intuitiva e de simples implementação. A primeira capta a tendência do capital humano enquanto a segunda capta o seu comportamento cíclico. Implementamos essa fórmula final usando dados de contas nacionais facilmente obteníveis para quase todos os países, o que torna a sua implementação imediata, somente requerendo a estimativa de um modelo de séries temporais para prever a variação da renda do trabalho.

A partir do uso de nossas novas estimativas para o capital humano, revisitamos a importância deste num contexto de função de produção agregada para dois grupos de países. Primeiro, para o grupo da OCDE, que inclui apenas países de renda per capita média e alta, com preponderância da última. Segundo, para um grupo bastante heterogêneo de 127 países com dados relativamente longos no tempo possibilitando estimativas de painel desbalanceado usando a Penn World Tables. Nossos resultados confirmam que a importância do capital humano para o crescimento econômico dos países tem sido subestimada na literatura. De fato, para os países da OCDE, encontramos uma elasticidade capital humano da produção de 0,10, contra 0,08 em estudos idênticos quando se usa os anos de escolaridade como proxy do

último. Entretanto, essa diferença é bem superior para os 127 países usados na Penn World Tables, onde nossas estimativas da elasticidade capital humano da produção chega a 0,86 – contra 0,12 obtidos a partir do uso de um Índice de Capital Humano disponibilizado nessa base de dados.

Keywords: Human Capital, Economic Growth, Panel-data Model, Growth-Accounting Exercises.

JEL Classsification: O47;D24;C23;

1 Introduction

Human capital represents personal productive knowledge, i.e., the stock of knowledge that can be used by a person in producing goods and services. It is a latent variable, i.e., non-observable. In the economic growth literature, a key proxy for human capital that has been used in cross-country growth regressions is the number of years of schooling after the work of Barro and Lee (1996). As stressed by De la Fuente and Doménech (2006) and Cohen and Soto (2007), one of its shortcomings is the fact that heterogeneity in schooling is not accounted for, since its quality is not measured: one year of schooling in an African country represents the same measure as one year in Europe, whereas standardized test results strongly reject this assumption.

In this paper we propose a novel measure of human capital that is based on market prices. In our case, based on the rewards to human-capital accumulation – real labor income. The main idea is relatively simple and is borrowed from the finance literature: Lettau and Ludvigson (2001), Campbell (1996), and Jagannathan and Wang (1996). Human capital should be equal to the expected present-discounted value of the real labor income stream received by the representative agent. We advance with respect to this literature in the way in which we implement the computation of this expected value. We circumvent the fact that labor income is a non-stationary process which requires special techniques to compute its future expectations. The work of Beveridge and Nelson (1981) provides a invaluable tool in that regard, showing that human capital can be expressed as a linear function of current real labor income and current real labor income changes.

Our market-price proxy of human capital has two interesting characteristics: first, it captures the well-known trend observed on the number of years of schooling, present in every country. Indeed, by its nature, it shares a common trend with real labor income. As is well known, real labor income is readily available in every country National Accounts as "Compensation of Employees." That includes not only wages and salaries, but a myriad of other forms of labor income received by workers. Second, its cross-country variation is much greater than that observed for the number of years of schooling. We believe that this is a consequence of the fact that it captures cross-country differences in the quality of human capital. We document that the coefficient of variation (unit free) of our proxy of human capital is 3 times that of years of schooling for OCDE countries, and more than 10 times when the Penn World Tables data base is used.

Using our new measure of human capital we estimate production functions using the techniques in Ferreira, Issler and Pessoa (2004), which are comparable to those on several papers in the economic-growth literature, e.g., Mankiw Romer and Weil (1992), Islam (1995), Caselli, Esquivel and Lefort (1996), De la Fuente and Doménech (2002, 2006), and Cohen and Soto (2007), *inter alia*. The results imply an increased human-capital elasticity in the production function vis-a-vis that obtained using years of schooling.

The rest of the paper is divided as follows. Section 2 provide the basis of our proxy and its computation formulas. Section 3 describes the growth models to be estimated and the techniques used. Section 4 presents the empirical results and Section 5 concludes.

2 Human Capital and Economic Growth

Numerous theoretical growth models have emphasized the role of human capital in explaining growth-rate differences of income per capita across countries, among them, Lucas (1988), Becker, Murphy and Tamura (1990), Rebelo (1992) and Mulligan and Sala-i-Martin (2000). Early empirical studies, such as Romer (1990), and Barro (1991), used proxies for human capital because of data limitations. Barro and Lee (1993) contributed to the widespread use of the mincerian approach in selecting the functional form of human capital in production. Their proxy of human capital is linked to years of schooling for the population with 25 years or more, obtained from UNESCO and other sources. Data were obtained for a up to 129 countries between the years 1960-1985. Barro and Lee report the average years of study at the five-year frequency. Prior to Barro and Lee, Barro (1991) used a sample of 98 countries proxying human capital either by the enrollment rate in secondary education for 1960 or in primary education for 1960. He finds estimated coefficients for these proxies equal to 0.02 and 0.03, respectively.

According to Caselli (2005), Mankiw, Romer and Weil (1992) made one of the most important contributions to the empirical literature on economic growth. Using the basic Solow model, the authors showed that the inclusion of human capital improved considerably the fit of the model to cross-country data. They employed a production function with additional two laws of motion for capital and human capital. Their identification strategy did not focus directly on the production function, but on a combination of the former with the steady-state conditions of the model: an equation relating output per capita with savings rates, population growth, depreciation, and technological progress.

Mankiw, Romer and Weil used as proxy for human capital the percentage of the economically active population enrolled in secondary education. An important caveat is made by the authors: "This variable, ..., is clearly imperfect: the age ranges in the two series data are not exactly the same, the variable does not include the input of teachers, and it completely ignores primary and higher education." Notwithstanding this caveat, the estimated coefficient for human capital is 0.28 for a sample of 98 non-oil countries, which is close to 0.31 – the estimated coefficient for physical capital. Because the fit of the model is considered to be good ($R^2 = 0.78$), there is little room for Total Factor Productivity (TFP) to explain the observed cross-country variation of output per capita.

On another important study, Hall and Jones (1999) decompose the changes in output per capita between the contribution of factors (capital and human capital) and productivity, using a mincerian functional form for human capital. On simulations using the model for 127 countries, Hall and Jones find that, even controlling for physical and human capital per worker, there is still a large portion of output-per-worker disparity left unexplained. Hence, total factor productivity (TFP) disparity can be an important factor in explaining the differences of output per worker across countries.

Ferreira, Issler and Pessoa (2004, 2005) estimate and test alternative functional forms of the production function used in the empirical growth literature. Using a Box-Cox test, with data from the Penn World Tables, they test the Cobb-Douglas functional form (Mankiw, Romer and Weil, 1992) against the mincerian formulation (Hall and Jones, 1999). Results show the appropriateness of the mincerian formulation in production. The final estimate for the capital share is 0.409, whereas each year of schooling increases income per capita by 9.09% on average, across countries. They also found TFP to be important in explaining the variation of output per worker.

Klenow and Rodriguez-Clare (1997) revisit the model of Mankiw, Romer and Weil (1992) using some adjustments in the human-capital proxy. In their results, human capital accounts for up to 33% of the variation in per capita income. Still, TFP disparity is an important factor in explaining the differences of output per worker across countries. Bils and Klenow (2000) calibrate a model to quantify the strength of the education effect on growth, using evidence from the labor-economics literature on returns to education and a mincerian approach. Their findings indicate that education explains less than one third of the growth across countries.

Caselli (2005) conducts several exercises to assess the quality of human capital data used in empirical growth studies. On years of education, and based on De la Fuente and Doménech (2002), he states that "such series are rather noisy, and this explains in part why human capital-based models often perform rather poorly." Regarding the focus on the average years of schooling for persons with 25 years and more, Caselli points out that this can be a bad choice for poorer countries that face higher education growth rates exactly in the range of persons under 25 years. Caselli has a list of suggestions to correct the difference in quality of education between countries: teacher-student relationship, the human capital of teachers, the use of standardized tests of basic learning, experience and health, etc.

Below, Table 1 presents a summary of empirical results on the impact of human capital estimated by cross-country studies. Here, output per capita is the dependent variable and we report a human capital coefficient estimated under different specifications and proxies of human capital.

Table 1 - Human Capital Impact on Selected Papers

Author	Human Capital Parameter
Barro (1991)[a]	Between 0.02 and 0.03
Ferreira, Issler and Pessoa (2000)[b]	Between 0.028 and 0.032
Cohen and Soto (2007)[c]	Between 0.017 and 0.123
De la Fuente and Doménech (2002)[d]	0.068
Mankiw, Romer and Weil (1992)[e]	Between 0.28 and 0.37

[a] Dependent variable: the real GDP growth rate; h_{it} = Enrollment Rate.

[b] Double log Model; h_{it} = average years of schooling.

[c] Double log Model; h_{it} proxy: based on enrollment rate and average years of schooling.

[d] Double log Model; h_{it} = average years of schooling.

[e] Double log Model; h_{it} = Enrollment Rate.

3 Data

In this study, we cover two different international data sets on economic growth. The first is the OCDE data base: a reduced number of middle to high income countries with uniformly collected statistics on National Accounts, including GDP, Investment, Labor Compensation, and on population, hours worked, etc. The OCDE data base includes data on 25 countries: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Greece, Germany, Iceland, Ireland, Italy, Japan, Luxembourg, Mexico, The Netherlands, New Zealand, Norway, South Africa , South Korea, Spain, Sweden, Switzerland, United Kingdom and United States. We used time-series from 1970 through 2010 on these variables and countries. For the sake of completeness, we also employed schooling data originally from Barro and Lee (1993) for comparisons with a popular alternative measure of human capital. The second data base used here is the Penn World Tables (PWT), on its newest version, 8.1. It includes a total of 167 countries with time-series from 1950 through 2011, at the most. Some countries with too much missing data were excluded from the estimated regressions, which ultimately comprised an unbalanced panel of 127 countries. PWT 8.1 has two interesting characteristics. It possesses data on Labor Compensation from National Accounts, which is a basic series in constructing real Human Capital using a present-value approach and it also possesses a novel Human Capital Index, that uses schooling data from Barro and Lee weighted by the respective return on schooling on each year. This estimate will also be compared with our final human-capital estimate.

A major contribution of this paper is to propose an estimate for the stock of human capital whose value has been priced by the labor market, i.e., we use prices (and also quantities) to retrieve human capital. We follow closely the idea put forth explicitly by Lettau and Ludvigson (2001, 2004), and previously discussed in Campbell (1996) and Jagannathan and Wang (1996), although none of these authors actually carried forward the present-value computation that is unveiled below. What is proposed by Lettau and Ludvigson is to consider the stock of human capital to be the expected present discounted value of the labor-income stream associated with it:

$$h_t = \mathbb{E}_t \left\{ \sum_{j=0}^{\infty} \rho^j W_{t+j} \right\}, \tag{1}$$

where $\rho = \frac{1}{(1+r)}$ is a discount rate and r is the real interest rate associated with it, $\{W_t\}_{t=0}^{\infty}$ is the stream of real per capita labor income accrued to the representative agent, and $\mathbb{E}_t(\cdot)$ is the conditional expectation operator, using information up to period t. Data on W_t is obtained by using "Compensation of Employees" readily available in every country National Accounts.

Using the tools in Beveridge and Nelson (1981), one can show that h_t is a linear function of W_t and ΔW_t, where the first captures the trend in human capital and the second captures its cyclical behavior.

4 Empirical Results

OCDE Data Set

To compute the level of physical capital in the OCDE data base we need to construct it from investment data using the *Perpetual Inventory Method*. That requires an initial capital stock value as pointed out by Young (1995). We approximate the initial capital stock by using $K_0 = I_0/(g_I + \delta)$, where K_0 is the initial capital stock, I_0 is the initial investment expenditure, g_I is the growth rate of investment, and δ is the depreciation rate of the capital stock – 6% per annum in the basic exercise.

After some experimentation and testing, our benchmark regression representing the Cobb-Douglas production function of the OCDE data base yields a physical capital elasticity of 0.5077 and a human-capital elasticity of 0.1038, both significant with high confidence. These estimates impose constant returns to scale in production – a hypothesis that we test and do not reject prior to estimation. Here, our proxy of human capital is used in estimation.

Next, we re-estimate the same production function with an alternative measure of human capital using the same data base otherwise. Now, estimation results yield a physical capital elasticity of 0.5171 and a human-capital elasticity of 0.0805, the former being highly significant, but not the latter. These estimates impose constant returns to scale in production – a hypothesis that we test and do not reject prior to estimation.

Comparing both sets of results we observe that there is little change regarding the physical capital elasticity in production, but the human-capital elasticity decreases by a sizable 22%.

It is instructive to try to understand why these results come about. For the 25 countries in our OCDE data base, we plot the two human-capital proxies side-by-side in dual scale for each country. This is presented in Figure 1 below:

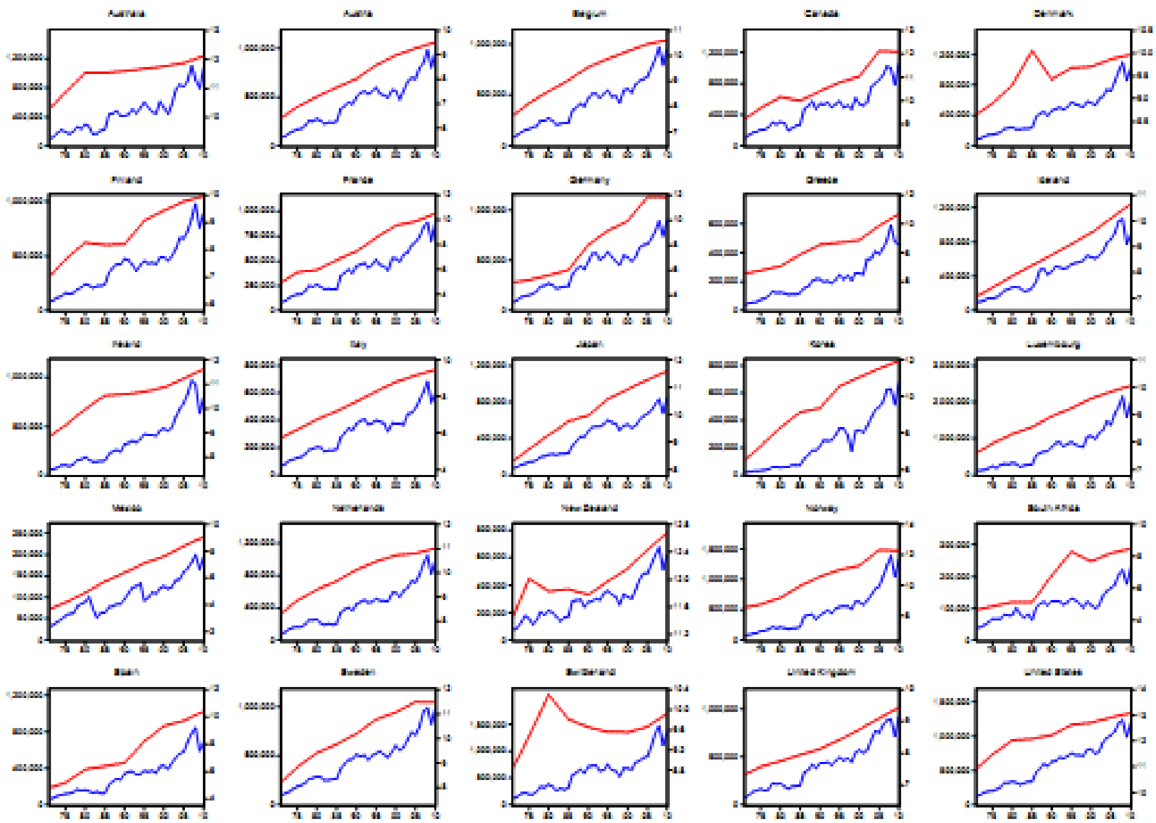

Figure 1: h_{it} and Barro and Lee's Years of Schooling (dual scale)

Apparently, for most countries, both proxies are co-trending, but schooling is much smoother than our proxy. There is another dimension in which our series has also more variation: across countries. Since both are measured in different units, to compare the cross-sectional variability of them we compute their coefficient of variation (mean over standard error). Whereas Barro and Lee's proxy has an estimated coefficient of variation of 0.20 that of our proxy is 0.73, more than three times Barro and Lee's.

Penn World Tables Data Set

We now apply the same techniques of the previous Section to the Penn World Tables, version 8.1. Again, we employed the *Share of labour compensation in GDP at current national prices* as a basis to construct W_t – real labor income per capita. In our sample, we considered 127 countries with data from 62 time-series observations from 1950 through 2011, forming an unbalanced panel.

It is instructive to compare our proxy with the new *Human Capital Index* in the data base. The latter combines information from the years of schooling in Barro and Lee (1993) and the returns to each year in Psacharopoulos (1994). This comparison is presented in Table 2. There are a few points to be noted. First, our proxy has a coefficient of variation of at least 10 times that of the Human Capital Index. Second, this difference is increasing across time. It was 10.80 in 1970 and it is almost twice of that in 2010, reflecting a very different dynamics over the last 40 years.

Table 2: Cross-Sectional Coefficient of Variation
Human Capital Index – H.C.I. – (PWT, 8.1) and Our Proxy h_{it}

	(1) H.C.I.	(2) Our Proxy h_{it}	Ratio (2)/(1)
Coeff. of Variation 1970	0.28	3.30	10.80
Coeff. of Variation 1990	0.22	3.09	13.80
Coeff. of Variation 2010	0.19	3.61	19.25

Figure 3.2 presents a plot with both proxies on a dual-scale setting for four selected countries in different continents. It looks like both capture the same upward trend in human capital. However, given, the results in Table 2, our proxy captures much more cross-sectional variation than does the Human Capital Index, which may contribute to explain the variation in output per capita in the panel.

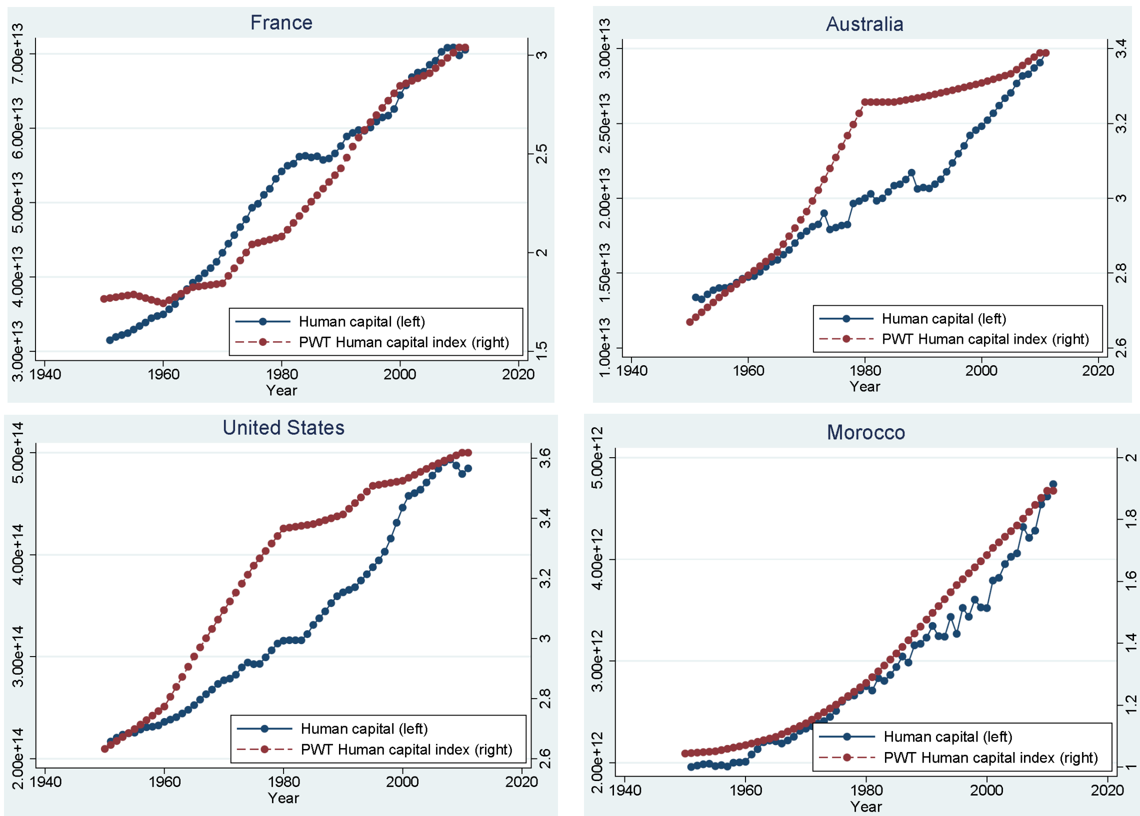

Figure 3.2: Human Capital Index (PWT, 8.1) and Our Proxy for Selected Countries

We followed the same testing protocol used for the OCDE data base. Below, we present our benchmark regression obtained after some experimentation and testing using our proxy of human capital in estimation. The Cobb-Douglas production function of the PWT data base yields a physical capital elasticity of 0.556 and a human-capital elasticity of 0.862, both significant with high confidence. Testing constant returns to scale in production is rejected for the PWT database.

Next, we re-estimate the same production function with an alternative measure of human capital – the Human Capital Index – using the same data base otherwise. Now, estimation results yield a physical capital elasticity of 0.681 and a human-capital elasticity of 0.118, the former highly significant but not the latter. Constant returns to scale in production is not rejected at 5% significance but is at 10%.

The difference in results is striking. Overall, there is much more room for factors to explain the variation of output per capita when our proxy for human capital is used in estimation. The human-capital elasticity increased by more than sevenfold, an impressive result. Also, this estimate is about 8 times the one obtained for the OCDE's data base. Since the human-capital proxy is the same in both data bases, the difference in results should be a consequence of the sample of countries used in the analysis[1]. Penn World Tables uses a variety of countries for which human capital is relatively low. For the panel as a whole, because the returns to human-capital for these countries are very high, we should expect an increase in the human-capital elasticity in production.

The comparison between our proxy of human capital and the Human Capital Index in PWT, 8.1, shows that using a proxy that is based on market prices (labor market) has the potential to increase considerably the human-capital elasticity in production, which, in turn, shows that this input may be more important for economic growth than previous research has found. One key exception that has estimates similar to the ones found here is Mankiw, Romer and Weil (1992), who employed the average percentage of working-age population in secondary school as a proxy for human capital. There, the human-capital elasticity in production was estimated to be on the range $0.28 - 0.37$. Still, this is less than half or a third of our estimate. Mankiw, Romer and Weil were criticized for finding an elasticity of human capital in production that was "too high." Klenow and Rodriguez-Clare (1997) revisit Mankiw, Romer and Weil and correct the human-capital proxy used in the analysis. They find that human capital can still explain 33% of the variation in income per capita. On the other hand, De la Fuente and Doménech's (2002) estimates of ϕ reached up to 0.95, but the mean estimate is much lower, 0.348.

5 Conclusions

In this paper we propose a novel way to measure human capital based on labor market data. Following the literature in finance, e.g., Lettau and Ludvigson (2001), Campbell (1996), and Jagannathan and Wang (1996), we

[1]There is also a small difference regarding the sample period as well.

assume that the stock of human capital is the expected present discounted value of all future labor income stream. In its simplest form, this allows writing human capital as a function of current real labor income and the first difference of current labor income. The first captures its long-run trend, and the second captures its cyclical behavior. As is well known, labor income is readily available in every country National Accounts as "Compensation of Employees." That includes not only wages and salaries, but a myriad of other forms of labor income accrued by workers.

Our human capital proxy has the advantage of being based on market prices. As economists, we are firm believers that market prices reveal information on economic decisions, such as the case for human-capital accumulation. Equipped with this new series, we revisit previous results obtained in the growth literature estimating aggregate cross-country production functions, where, most of the time, human capital was proxied by the average years schooling, sometimes with a mincerian correction for the contribution of each year of schooling. We show that using a proxy that is based on market prices (labor market) has the potential to increase considerably the human-capital elasticity in production, which, in turn, shows that this input may be more important for economic growth than previous research has found. This was put to test using two distinct data bases on cross-country economic growth – the OCDE database and the Penn World Tables, version 8.1.

Next, we summarize the main empirical results of the paper:

1. When we used the OCDE database of 25 middle- and high-income countries, with data between 1970 and 2010, the aggregate production function was estimated with and without the imposing homogeneity of degree one in production. Employing the new measure of human capital increases its elasticity in production from 0.081 to 0.104, whereas the latter is significantly different from zero but the former is not.

2. When we used the Penn World Tables, 8.1, comprising an unbalanced panel of 127 countries, with data from 1950 through 2011, the changes in human-capital elasticity in production were much more profound. Human-capital elasticity jumped from 0.12 to 0.86, about a sevenfold increase, when we employed the new proxy proposed here. This comparison was made using the recently created *Human Capital Index*, provided in PWT, 8.1, which encompasses information from the years of schooling and their respective returns as calculated by Psacharopoulos (1994).

3. It is interesting to note that our final estimate of the human-capital elasticity in production is about 2 or 3 times larger than that found by Mankiw, Romer, and Weil (1992). They used the average percentage of working-age population in secondary school for the period 1960-1985 as a proxy for human capital. Their estimates were in the range $0.28 - 0.37$, while ours was 0.86. Thus, our estimate points out to a much more prominent role for human capital in growth studies than previously thought.

As future work, we intend to perform a variety of robustness studies using the Penn World Tables data base. We also intend to perform a variety of growth-accounting exercises to evaluate the importance of human capital, as well as a variety of counter-factual exercises employing our estimated parameters.

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