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Literacy, Human Capital and Grwoth

by
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Summary: We derive synthetic time series over the 1960-1995 period on the literacy level of labor market entrants from the demographic profile of the 1994 International Adult Literacy Survey. This information is then used as a measure of investment in education in a two-way error correction panel data analysis of cross-country growth for a set of 14 OECD countries. The central result of the paper is that direct measures of human capital based on literacy scores outperform measures based on years of schooling in growth regressions. The results indicate that, overall, human capital indicators based on literacy scores have a positive and significant effect on the transitory growth path, and on the long run levels of GDP per capita and labor productivity.

Keyword: Human capital, growth regressions, convergence, gender gap, literacy
JEL classification: I20, J16, O30, O40, O57

Résumé
Nous établissons, pour la période de 1960 à 1995, des séries chronologiques synthétiques du niveau de littératie des entrants sur le marché du travail d'après la structure par âge de l'Enquête internationale sur l'alphabétisation des adultes, menée en 1994. Puis, nous utilisons ces renseignements pour mesurer l'investissement dans l'éducation en procédant à une analyse de données de panel sur la croissance transnationale d'un ensemble de 14 pays de l'OCDE. Selon la principale constatation de notre étude, les mesures directes du capital humain fondées sur les résultats en littératie s'avèrent plus exactes que les mesures fondées sur le nombre d'années de scolarité dans les régressions de la croissance. Les résultats montrent que, dans l'ensemble, les indicateurs du capital humain fondés sur les résultats en littératie ont un effet positif et significatif sur le sentier de croissance transitoire et sur les niveaux à long terme du PIB par habitant et de la productivité du travail.

Mots-clés : capital humain, régressions de croissance, convergence, écart entre les sexes
Classification JEL : I20, J16, O30, O40, O57

1. Introduction

The role of human capital in explaining cross-country differences in well-being has received considerable interest in the recent economic growth literature[1]. In studies of broad sets of countries, including developed and developing countries, standard measures of human capital based on educational achievement are usually found to have a positive and significant long run level effect on countries' GDP per capita and a transitory positive effect on economic growth during the convergence process toward the steady state (Barro, 2001). However, when the sample under study is restricted to developed countries, the estimated effect of human capital or education on economic growth is not significant, sometimes null, or even negative (Islam, 1995; Barro, 2001, Krueger and Lindahl, 2001).

One of the reasons behind this puzzling result may be associated with the fact that human capital is not straightforward to measure given that it is not usually exchanged in markets like other economic goods. For this reason, human capital is typically measured indirectly from educational attainments and/or enrolment rates. But such human capital indicators are often subject to comparability problems at the cross-country level given the wide variety of educational systems around the world.

In a recent contribution to the topic, De la Fuente and Doménech (2002) address the data quality issue and conclude that the growth effect of corrected (for measurement errors) average schooling indicators across 21 OECD countries is positive and significant. Although the data constructed by De la Fuente and Doménech represents a substantial improvement relative to earlier datasets, including those of Barro and Lee (1993;1996), it is nonetheless based on schooling data and therefore subject to comparability issues.

In this paper, we introduce a novel approach for the use of human capital indicators in growth empirics, based on direct measures of human capital constructed from literacy test

[1] See for example, the pioneering contributions of Mankiw, Romer and Weil (1992), Islam (1995), and the more recent work of Temple (2000), Bassanini and Scarpetta (2001) and Barro and Sala-i-Martin (2004).

scores. The literacy raw data come from the 1994 International Adult Literacy Survey (IALS), which tested the skills of individuals aged between 16 and 65 and is available for fourteen OECD countries. A historical perspective on human capital accumulation is required to appropriately test the growth effects of investment in education. We use the age distribution of test results to construct a synthetic time series, over the 1960-1995 period, of the literacy level of the young cohort entering the labor market in each period. The relative literacy level of these cohorts is seen as an indicator of a country's investment in human capital relative to the other countries in the sample.

Direct measures of human capital have been used previously in growth regressions by Hanushek and Kimko (2000) and Barro (2001). They consider measures of schooling quality based on student performance in international assessments of science and mathematics. However, their data source provides them with a single cross-section of human capital indicators. Therefore, their analysis abstracts from the time-series dimension of human capital investment. The innovative methodological contribution of our paper consists in deriving time-series data based on direct measures of human capital.

Results indicate that our human capital indicators based on literacy tests have a positive and significant effect on the long run levels of GDP per capita and labor productivity, and on the growth rate in the transitory process toward steady state. Moreover, in our restricted set of OECD countries, the human capital data based on literacy test scores are found to contain more information about the relative growth of countries than the corrected schooling data used in De la Fuente and Doménech (2002).

Given the detail of the available data on literacy, we are also able to explore the relationship between growth and the distribution of human capital. In particular, we find that human capital indicators based on average literacy scores per country have a stronger effect on growth than comparable indicators based on the percentage of the population that achieved top scores. This result suggests that productivity is mostly influenced by the effect of skills and human capital accumulation on the general labor force, rather than their effect on highly specialized labor only.

Interestingly, all of our results by gender indicate that the growth effects of human capital indicators based on female literacy are stronger than the effects measured from indicators of male literacy. We get this insightful result even when controlling for fertility[2]. These findings contrast sharply with those of Barro (2001) who found that female education had no significant effect on growth when fertility is included in the set of explanatory variables. Our results are however consistent with the gender-specific effects of educational attainment found in other studies. For example, Hill and King (1995) provide evidence that women education has a positive and significant effect on GNP and that gender gaps in enrolment rates are detrimental to growth[3]. Schultz (1995) finds that female school enrolments have a larger positive effect on growth than men enrolments, while Dollar and Gatti (1999) report, for a sample of developed countries only, that indicators of female educational attainment have a positive and significant effect on growth in contrast to the effect estimated from indicators of male education.[4]

The remaining of the paper is organized as follows. Section 2 presents the literacy data and provides details regarding the construction of the synthetic time series used in the empirical analysis. The methodology used to conduct the regression analysis is discussed in section 3. The methodology is straightforward and has been used elsewhere in the literature (Barro and Sala-i-Martin, 2004). Results are presented and analyzed in section 4. We conclude with a discussion of the limitations of our analysis and suggest directions for further research.

2. Data

Human capital indicators are based on the results of the 1994 International Adult Literacy Survey (IALS), which assessed the literacy proficiency of representative samples of

[2] These results are consistent with Psacharopoulos (1994) who provides microeconomic evidence that the rate of return on women education is slightly higher than that of men.
[3] Galor and Weil (1996) and Knowles, Lorgelly and Owen (2002) present theoretical models consistent with a negative relationship between the gender gap in education and economic growth.
[4] Similar results are found in Forbes (2000) and in Caselli, Esquivel and Lefort (1996), although the effect of male schooling is both negative and significant in the latter study.

individuals aged between 16 and 65[5] over three skill domains – prose literacy, document literacy and quantitative literacy. The tests measured the ability of individuals to accomplish various tasks across a range of difficulty levels. The tests were designed to sample everyday tasks that would not provide any advantage or disadvantage to particular groups due to familiarity, language or culture, among other things.

Synthetic time series for the 1960-1995 period were constructed from the cross-section data using the age distribution of test results, under the assumption that the level of human capital remains constant throughout individuals' lives.[6] We use the literacy results of individuals aged 17-25 in each country in a particular period as proxies for the relative human capital investment of each country during the previous period. Survey results are available both as average test scores and as percentages of individuals who have attained different literacy levels - 1 to 5 - thought to be associated with particular sets of skills. Both forms of survey results will serve as human capital indicators. The data is available for 14 countries[7] and can be broken by gender groups. The data on average test scores in each country, for the three skill domains (prose, quantitative and document) and the average over the three tests (literacy) are presented in the Appendix.

In contrast to human capital indicators based on schooling enrolment or attainment, these indicators provide a direct measure of the quality of human capital and are not subject to various problems related to the comparability of education systems across countries. Moreover, direct measures of human capital capture additional sources of variance not captured by years of schooling or enrolment rates, including variance in the quality of the educational experience across time, across groups of individuals and across regions. Hence, these indicators are expected to contain more information about the productive capacity of human capital than educational data. In fact, there is microeconomic evidence suggesting that the skills measured by IALS explain a

[5] Older individuals were tested in some countries.
[6] See Appendix F in Coulombe, Tremblay and Marchand (2004) for an overview of the IALS study, how the synthetic estimates were derived, what is known about the skills relationship to economic growth and their suitability for the present use.
[7] These countries are Belgium (Flanders), Canada, Denmark, Finland, Germany, Ireland, Italy, Netherlands, Norway, New Zealand, Sweden, Switzerland, United Kingdom and the United States.

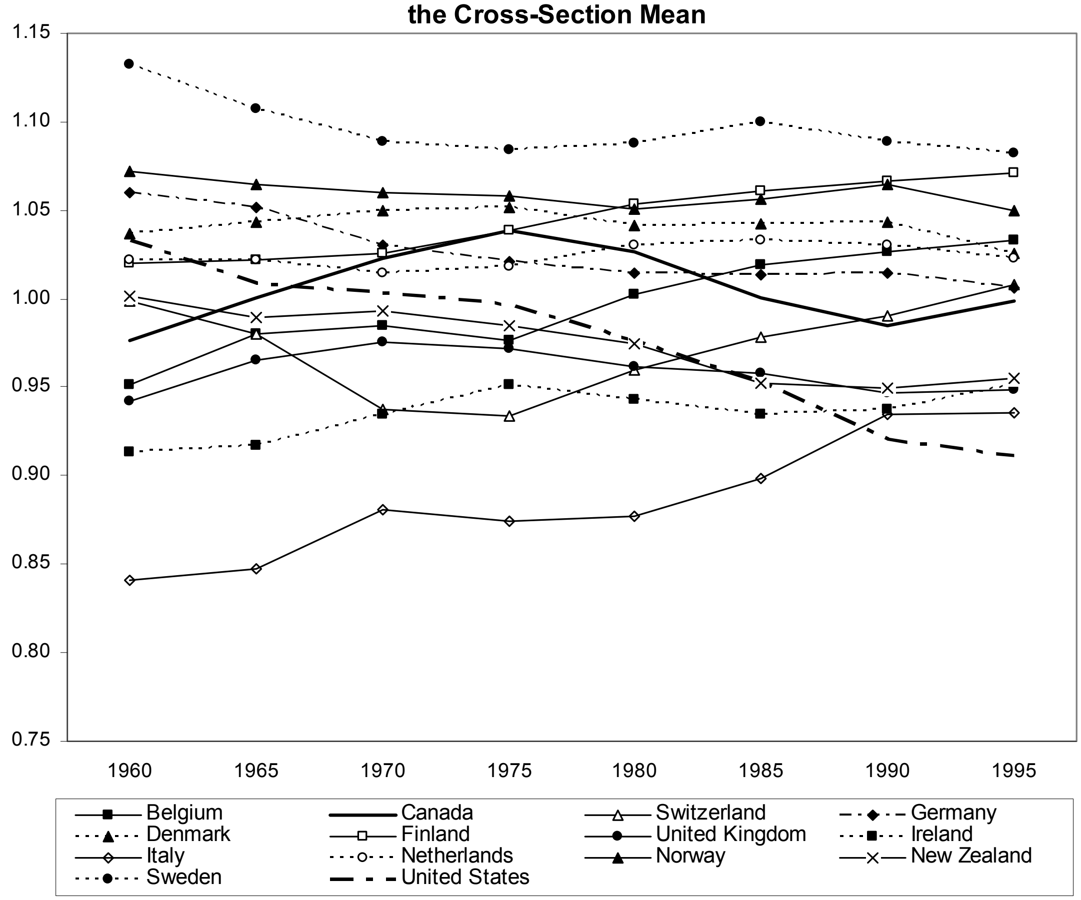
substantial part of wage earnings and labor market outcomes, independently of the effect of education. In particular, Green and Riddell (2001) have found significant wage returns in the Canadian labor market associated with literacy proficiency measured from IALS data, while controlling for educational attainment. [8]

Of course, our human capital indicators are not without shortcomings. For instance, the fact that the construction of the synthetic time series from the cross-section data cannot take account of migration flows over the period is an important drawback. Moreover, our indicators impute levels of literacy to individuals earlier in their lives, without correcting for the adjustment in the quality of human capital that occurs during an individual's lifetime through learning and human capital depreciation. This is a disadvantage of our indicators relative to schooling data. If individuals' human capital tends to grow during post-school life, our indicators would tend to overestimate the human capital investment made before individuals entered the labor market.

Average literacy test scores of the population aged 17-25 relative to the cross-section mean are depicted in Figure 1. Scandinavian countries are performing very well. Sweden has had the highest average score throughout the period and Finland improved from 6th to 2nd place. Italy, which had the lowest score in 1960, improved substantially from 84% of the average to 94% in 1995. In contrast, the United States recorded the largest decline from 103% of the average to 91%, going from 5th to last place.

[8] The coefficient of correlation, over the 1960-1995 period, between our measure of human capital based on the average literacy score and the average years of schooling variable from de la Fuente and Doménech (2002), all expressed as deviations from the cross-section mean, is equal to 0.38.

Figure 1: Average Literacy Score of Population Aged 17-25 Relative to the Cross-Section Mean



The data on GDP per capita, GDP per worker[9], investment as a share of GDP, imports and exports are from the Penn World Tables (version 6.1). These variables are expressed in purchasing power parities (PPP), which allows real quantity comparisons to be made across countries. GDP per capita is also adjusted for terms of trade changes. The openness ratio is the sum of exports and imports as a share of GDP, averaged over 5-year periods and adjusted for the size of countries measured by population and land area. Fertility rates are from the United Nations' database. Fertility and investment rates are also taken as averages over five year periods.

[9] GDP per worker and labor productivity are considered equivalent expressions in the remaining of the text.

3. Empirical Methodology

3.1 The panel data model

The relationship between various human capital indicators and economic growth is analysed using an empirical approach, the convergence-growth regression, which is based on the theoretical analysis of Mankiw, Romer and Weil (1992), and Barro and Sala-i-Martin (1992). In the convergence-growth framework, the growth rate of the economic indicators such as GDP per capita and labor productivity, $Y_{i,T}$, for country *i* during period *T* is determined by its initial level, by a set of environmental and control variables $Z_{i,T}$, and by a stochastic term $v_{i,T}$ that captures the effect of country-specific shocks that temporarily affect economy *i* during period *T*.

Following Coulombe and Lee (1995), Islam (1995), and many subsequent studies, we pool time series and cross-country information in a panel data approach to study the convergence-growth relation. The panel approach to growth regressions is now recognized as having numerous advantages over the pure cross-country approach that was first used by Barro (1991), Barro and Sala-i-Martin (1992) and Mankiw, Romer and Weil (1992), as discussed in Temple (1999), since it exploits the information contained in the time series evolution of the cross-sections of countries during the period under study. Furthermore, the pooling of time series and cross-sectional information is particularly welcome in the present empirical analysis given the limited number of cross-sections (14) covered by literacy data.

In a panel data model, $\Delta Y_{i,t}$ is given by:

$$\Delta Y_{i,t} = F(Y_{i,t-1}, Z_{i,t-p}, \varepsilon_{i,t}),$$

where $t = 1,...,T$ and p is the number of lags (usually 0 or 1) used for the Z variables. As in Islam (1995) we will use five year time intervals between periods t and $t+1$. For values of p equal to 0 or 1, the panel setup will use NT observations between period 0 and period t.

The combination of time series and cross-sectional information in growth regressions has to be done very carefully since the two types of information are not comparable in a straightforward manner. First, common trends and common shocks (such as the productivity slowdown or the oil shock) to the *Y* and *Z* variables have to be extracted from the time series observations in order to obtain unbiased results. To tackle this issue, we follow the familiar approach in panel data analysis of defining the *Y* and *Z* variables as logarithm deviations from the cross-sectional sample mean. This approach is equivalent on theoretical ground to introducing *T*-1 time dummies λ_t in the panel data regressions. Second, we control for time invariant heterogeneity across countries using country-specific fixed-effects μ_i. Remember however that with a fixed effect approach, we cannot use time-invariant control variables such as a rule-of-law indicator, a democracy indicator, or country size in the regressions. Our empirical strategy is designed to focus on the time series dimension embedded in the demographic profile of the literacy score data base. In the terminology of Baltagi (1999), our panel data model might be viewed as a two-way error component regression model:

$$\Delta Y_{i,t} = \beta Y_{i,t-1} + Z'_{i,t-P}\,\phi + v_{i,t},$$
$$\text{where } v_{i,t} = \mu_i + \lambda_t + \varepsilon_{i,t}.$$

The growth-regression equation tested in the first empirical setup directly follows from Mankiw, Romer and Weil's (1992) and Islam (1995):

$$\Delta Y_{i,t} = \beta Y_{i,t-1} + \varphi_1 S(k)_{i,t} + \varphi_2 S(h)_{i,t-1} + \varphi_3 n_{i,t} + v_{i,t}, \qquad (1)$$

In this setup, *i*, 1, …, 14 for the 14 OECD countries (13 only in labor productivity regressions) in the sample and $t = 2, \ldots, 8$ where period 1 corresponds to 1960 and period 8 to 1995. The first growth rate data used in the regression are for the period 1960-1965 (period 2). The investment ratio variable $S(k)_{i,t}$ is the mean ratio of investment to GDP in period *t* and $n_{i,t}$ is the fertility rate in period *t*. The key variable of interest in this empirical analysis are the $S(h)_{i,t-1}$ for which a variety of human capital investment indicators will be used including indicators based on literacy scores and others based on schooling attainment. The measures of human capital investment derived from literacy data for the period 1960-1965 (period 2) are based in this empirical setup on literacy scores for the 17 to 25 age group in 1960 (period 1). The point estimate of the β parameter is a measure of the average speed of convergence across the 14 countries of the sample. Compared with Mankiw, Romer and Weil's (1992) original specification, given that our variables are all measured as logarithm deviations from the cross-sectional sample mean, this econometric setup implies that we assume equal growth rates of technological progress and equal depreciation rates across countries. With the cross-country fixed-effects, we also allow for different levels of technology across countries.

Under the assumption that physical and human capital investment ratios are on their steady-state growth path, Mankiw, Romer and Weil (1992) show that the share of physical capital and human capital in national income, α and η respectively, can be computed from the point estimates of the parameters β, ϕ_1, and ϕ_2 of (1) in the following way:

$$\hat{\varphi}_1 = -\hat{\beta}\left(\frac{\alpha}{1-\alpha-\eta}\right) \qquad (2)$$

$$\hat{\varphi}_2 = -\hat{\beta}\left(\frac{\eta}{1-\alpha-\eta}\right) \qquad (3)$$

We will be using these relations to provide estimates of human (and physical) capital shares for a variety of human capital indicators.

As shown in the work of Barro and Sala-i-Martin (2004), there is no reason to restrict the set of environmental variables Z to the usual one implied by the simple augmented Solow growth model, i.e. population growth (or fertility) and investment ratios for physical and human capital. Other variables that might affect the production function have proved successful in explaining long run cross-country differences. In this general growth regression setup, human capital indicators (investment or stock data) might be viewed as one fundamental determinant, among others, of the long run steady state.[10] For a broad set of countries including developed and less-developed countries, many candidate variables can be used as control for long-run steady states. The choice in our study of 14 developed countries is more limited for two reasons. As show in Barro (2001), many control variables that are significant in the broad set of countries, including government consumption as a share of GDP, rule-of-law indices and the inflation rate, are not significant when the sample is restricted to OECD countries. Second, as already mentioned, the use of the two-way error correction model implies that we cannot also control for time invariant and country invariant variables.

We are however able to control for an international openness variable $OPEN_{i,t}$. The increase in international openness in the period under study is one of the most important macroeconomic developments that affected the developed countries. Following Barro (2001), the degree of international openness is first measured as the ratio of exports plus imports over GDP. This measure is then filtered from the effect of population and geographic size from a simple panel data regression. Our benchmark panel data model is the extended version of (1) that includes the openness variable:

$$\Delta Y_{i,t} = \beta Y_{i,t-1} + \varphi_1 S(k)_{i,t} + \varphi_2 S(h)_{i,t} + \varphi_3 n_{i,t} + \varphi_4 OPEN_{i,t} + v_{i,t}, \qquad (4)$$

where the $v_{i,t}$ is defined as in the regression set-up (1).

The long-run level effect of a permanent shock to the four control variables Zi can be computed from the long run solution to equation (4), where $\Delta Y_{i,t} = 0$ at $Y = Y^*$. Thus, the long run elasticities for the various z are:

$$\frac{\partial y^*}{\partial z^*} = -\frac{\hat{\varphi}_z}{\hat{\beta}} \qquad (5)$$

[10] For a discussion on using investment versus human capital stock data in growth regressions in relation with micro empirical studies, refer to Kruger and Lindahl (2001).

3.2 Estimation techniques

Many alternative estimation techniques are available for pooled time series cross-section observations in convergence-growth regressions. Given that the purpose of the analysis is to evaluate the impact of alternative measures of human capital in growth regressions, we follow as closely as possible the estimation techniques used in Barro and Sala-i-Martin (2004) in their empirical analysis of a cross-section of countries. Barro and Sala-i-Martin (2004) present results for both the polling of 5 year and 10 year intervals. Given the nature of our human capital investment data based on cohorts, we adopt a panel data approach using five-year intervals.

The per capita GDP ($Y_{i,t-1}$) that enter the regression for the growth rate in the 1960-1965 period is the initial level in 1960. We have included the earlier value ($Y_{i,t-2}$) in the list of instruments in all IV estimations. As pointed out in Barro and Sala-i-Martin (2004), this procedure lowers the tendency to overestimate the convergence speed due to measurement error. The use of the two-period lagged dependant variable as instrument also decreases Nickell's (1981) bias associated with fixed effect estimators of dynamic panel data when the number of time periods is not large. This bias is in the same direction than the measurement error bias. Given that per capita GDP (and labor productivity) data were available in 1955 for all countries, the instrumentation of the lagged dependant variable did not translated into a loss of observations in the 1960-1995 sample.

The use of instrumental variables may also allow to overcome the problem of endogenous explanatory variables. To this end, the lagged level of fertility, physical investment, and openness variables are also included in the list of instruments. We also use the lagged schooling variable taken from de la Fuente and Doménech data bank as instrument for the human capital investment variables based on literacy scores. We also report results when instrumental variables are not used for the literacy variable in regressions dealing with the comparison between schooling and literacy data.

For the main set of results, we use system estimations with instrumental variables (IV) from iterated weighted two-stage least squares (WTSLS) to account for cross-sectional heteroskedasticity. We computed White heteroskedasticity consistent standard errors (HCCME) that allow for asymptotically valid inferences in the presence of the remaining time series heteroskedasticity. For the set of results dealing with the comparison between schooling and literacy data, we also use generalized least-squares estimations using cross-sectional weighted regressions to account for cross-sectional heteroskedasticity. In both cases, we used iterative techniques for updating coefficients and the weighting matrix. These estimates are respectively labeled in the tables as iterated feasible generalized least-squares (IFGLS) and iterative weighted two-stage least squares with instrumental variables (IWTSLS-IV).

Tests for AR(1) serial correlation using the residuals from IWTSLS-IV regressions based on the *t* statistic of the lagged residuals in modified regressions indicates that the null hypothesis of no serial correlation cannot be rejected.

4. Results

4.1 Basic Model

Regression results for the conditional convergence of GDP per capita, following equation (1) and using average test scores of the population aged 17-25 as human capital investment measures, are displayed in Table 1. The estimated convergence speeds are highly significant and correspond to annual rates of around 6.5 per cent, which are higher than that estimated by Mankiw, Romer and Weil (1992) for their OECD sample but somewhat below those obtained by Islam (1995).[11] Investment rates are highly significant in all regressions but fertility rates are not, although they have a negative sign as predicted by the neoclassical growth framework.[12]

[11] In the setup of equation 1 with 5 year time periods, the annual convergence speed is $-\log(1+5\beta)/5$.

[12] Results of these regressions using IFGLS can be found in Coulombe, Tremblay and Marchand (2004). Point estimates of the various parameters are very similar across comparable IFGLS and IWTSLS-IV regressions. Interestingly however, the effects of various literacy measures appear to be estimated more precisely with IWTSLS-IV than with IFGLS. Broadly speaking, the presence of an endogenous variable on

INSERT TABLE 1 HERE

Most importantly, the effect of human capital indicators on GDP growth is positive and significant at the 5 per cent level in all cases. This result contrasts sharply with most previous attempts to estimate the effect of human capital on growth across developed countries, with the exception of de la Fuente and Doménech (2002). Interestingly, the estimates are very similar for the different indicators of human capital considered; suggesting that the amount of information embedded in the three specific measures of literacy (prose, quantitative and document) is very comparable.

Note that, although the estimated coefficient on literacy is positive and significant, the direction of the causality between per capita GDP growth and literacy is *a priori* unclear. Both the initial level of GDP per capita and the literacy indicator are used as explanatory variables, although the level of GDP per capita is itself a function of human capital. In fact, in an open economy with perfect capital mobility for the financing of physical capital, the level of GDP per capita is determined entirely by the stock of human capital, and the convergence of GDP per capita is determined by the convergence of the human capital stock (Barro, Mankiw and Sala-i-Martin, 1995). Human capital may also drive economic growth if, for example, highly educated individuals are attracted and able to migrate to more prosperous countries, or if economic growth generates human capital through learning-by-doing. The possibility of reverse causality is particularly relevant in our analysis, given that our human capital investment measures are based on literacy tests performed at the end of the period of analysis, and are therefore somewhat distorted, among other things, by the migration flows that occurred over the period.

Under the assumption that the economies are in their steady state, we can compute the shares of physical and human capital retribution in national income, implied by the regression results as shown in equations 2 and 3. For the four literacy measures, these implied shares are between 0.25 and 0.27 and between 0.46 and 0.48 for physical and

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the right-hand side of a regression without IV might translate into both biased estimates and variance problems. In our specific case, it appears that the point estimates of the various parameters are not biased with IFGLS but they can be more accurately estimated with the IWTSLS-IV technique.

human capital respectively. This estimated share for physical capital is roughly consistent with the observed share of profits in national income of developed countries, which is typically around 30 per cent and fairly constant over time. The shares implied by our regression results leave approximately 30 per cent of national income for the retribution of raw labor, which implies that 2/5 of wages correspond to the retribution of raw labor and 3/5 represent the returns to skills. These results on the human capital share are consistent with the findings of Mankiw, Romer and Weil (1992) and Coulombe and Tremblay (2001).

Recall that country fixed effects that account for various forms of heterogeneity across countries are included in all the regressions. The inclusion of country fixed effects improves the precision of the estimated impact of human capital indicators, among other things.[13] They could also account for heterogeneity in the quality of the literacy data across countries. For example, contrary to other countries for which the coverage is complete, literacy data for Belgium cover only the population from the (relatively rich and educated) Flanders region. Of course, the GDP data refer to the whole country and the relationship between literacy and GDP growth might be substantially different for Belgium. Not surprisingly, the fixed effect for Belgium is always negative and significant (with p values around 1per cent) indicating that overall country’s growth (including Flanders and Walloon) is overestimated by the independent variable (excluding fixed effects) since the literacy indicators are based only on the rich region.

4.2 GDP per capita versus labor productivity

Following Barro (2001), we have included the openness ratio in our conditional convergence regressions based on the econometric set up of equation 4 in all the remaining regressions. Results for the convergence of GDP per capita and GDP per worker are presented in Table 2. In all regressions dealing with labor productivity growth, Germany had to be excluded from the sample since the time series is not available for the whole country prior to the reunification in 1990. As expected, the

[13] See Coulombe, Tremblay and Marchand (2004) for regression results without country fixed effects.

estimated effect of openness on growth is positive and significant in all cases. The regression results for the other determinants of growth are quite similar in the closed- and open-economy version of the model, which illustrates the robustness of the estimated relationships.

INSERT TABLE 2 HERE

Interestingly, the point estimates of the literacy variables are higher, and the parameters are generally estimated with more accuracy (smaller p value) in the regressions dealing with labor productivity rather than GDP per capita. In addition to further illustrating the robustness of the relationship between human capital and growth, these results suggests that the impact of literacy on living standards is not driven by labor market effects. If the effect of literacy on growth were only significant for per capita GDP, one could argue that the underlying augmented neo-classical framework is rejected since the effect of human capital investment on living standards is restricted to its effect on unemployment and participation rates. But the effect of human capital is more substantial on labor productivity, which indicates that the primary effect of human capital investment on living standards comes from its role in the broad capital accumulation process, as predicted in the underlying theoretical framework.

In order to provide an indication of the quantitative implications of our results, we report in Table 2 the long run elasticities of GDP per capita and GDP per worker with respect to physical and human capital accumulation implied by the regression results following equation (5). However, before interpreting these results, it is important to point out that, in the neoclassical growth framework, as long as the convergence speed is positive, variables like fertility, literacy (human capital), or the investment rate will only affect the level of long run GDP per capita or labor productivity; the steady-state growth rate being determined solely by the growth rate of technological progress. But in growth regressions, the convergence speed is typically rather slow, between 2 and 6 per cent per year. Consequently, it takes a long time period to reach the new steady state and the transitory effect of a human capital shock on GDP per capita or labor productivity can last for a concomitantly long time. In fact, following a human capital shock, with convergence speeds of 2 and 6 per cent, the economy will respectively need 35 and 11⅔ years to close half of the gap to the new steady state. Therefore, in a slow convergence world, the difference between long run growth and level effects may not be that important. However, it is more accurate to measure the impact of a shock by its long run accumulated effect on the steady state level of GDP per capita or labor productivity rather than looking at the impact measured by the point estimate of the human capital variable.

Hence, the elasticities implied by our regression results based on average test scores of 17-25 year olds indicate that the long run effects of human capital investment in literacy are substantial. A country that achieves literacy scores one per cent higher than the average ends up in a steady state with labor productivity and GDP per capita respectively higher than other countries by approximately 2 and 1.4 per cent on average. This result holds whether literacy is measured by prose, quantitative or documents skills. However, as will be shown in section 4.5 below, it is important to point out that this result is not independent of the scale used to report literacy scores.

4.3 De la Fuente and Doménech corrected schooling data

Table 3 reports results for the conditional convergence of GDP per capita and GDP per worker, using average years of schooling in the population as measures of human capital, taken from the de la Fuente and Doménech data set. In the regressions reported in the first, second, fourth and fifth columns, literacy is not included in the set of independent variables. In this case, the average years of schooling variable has a positive and marginally significant effect (p-value of 5.6 per cent) on per capita GDP growth when estimated with IFGLS only, but not on labor productivity.

INSERT TABLE 3 HERE

The regressions reported in the third and last columns include both the de la Fuente and Doménech schooling measure and our literacy measure based on average test scores of the population aged 17-25. In this case, the average years of schooling does not have a significant effect on either GDP per capita growth or labor productivity growth, while the literacy measure has a positive effect, significant at the 5 % level on the growth of GDP per capita and at the 1 % level on the growth of productivity.

These findings suggest that literacy scores data contain more information on the relative wellbeing of nations than the years of schooling data. We believe that this is the central result of our study and we suggest three potential explanations for it. First, literacy scores might be a better measure of an important determinant of growth, such as human capital, than years of schooling. This may simply result from the fact that literacy tests are direct measures of skills, contrarily to years of schooling. Second, at a given point in time, literacy data might be more comparable on a cross-country basis than years of schooling given that educational systems vary considerably across countries. Skills acquired from a year of schooling might differ significantly across countries. Third, in a given country, literacy data might be more comparable on a time series basis than years of schooling. What has been learned from a year of schooling in 1960 in one given country may not be directly comparable with has been learned with one year of schooling in 1990.

4.4 Percentage of the population that achieved specific literacy levels

We now briefly examine the relationship between the distribution of skills and economic growth. Table 4 reports the results of conditional convergence regressions in which the human capital measures are based on the percentages of individuals that attained at least level 4 on a particular literacy test. Only the indicator based on prose skills is found to have a significant effect on growth, and the point estimates of these human capital measures are much lower than those based on average scores, for each of the prose, quantitative and document literacy domains. These results suggest that measures based on the average test scores over all individuals are better indicators of the aggregate level of human capital investment than measures based on the proportion of individuals that achieved relatively high levels of literacy.

INSERT TABLE 4 HERE

This finding also implies that the distribution of human capital investment may be important for long run standards of living. In particular, it is consistent with the view that human capital investment fosters growth mostly by making the overall labor force more productive, as opposed to developing highly talented individuals who may, among other things, have a positive impact on growth through their contribution to innovation and technological progress.

We also ran a series of regressions in which we included the share of individuals that achieved only level 1 as explanatory variables, as opposed to the share of the population that achieved at least level 4. Relative to the cross-country average, this measure may be seen as an indicator of under-investment in human capital, which may act as a drag on growth.[14] For these indicators, we found that the lack of investment in the prose skills of the population and in all three types of literacy skills of men had a negative and significant effect on the growth of GDP per capita. For GDP per worker, the document skills of men and the prose skills of women were found to have a negative and significant effect on growth.

4.5 Results based on Female versus Male Literacy

In order to compare the relative contribution to growth of investment in the human capital of men and women, we analyzed the conditional convergence of GDP per capita and of labor productivity, using separately the average literacy scores of men and women as human capital investment measures. Regression results are presented in Table 5.

INSERT TABLE 5 HERE

Undoubtedly, investment in the human capital of women appears to have a much stronger effect on subsequent growth than investment in the human capital of men. For both GDP

[14] The regression results can be found in Coulombe, Tremblay and Marchand (2004).

per capita and GDP per worker, the estimated coefficients are larger and more significant for the literacy levels of women compared to that of men. While investment in the literacy of men has a significant effect at the 10 percent level on GDP growth and at the 5 per cent level on the growth of productivity, investment in women's literacy has a significant effect at the 1 per cent level on both productivity growth and GDP per capita growth. In the third and last columns, we report the results of regressions that include both male and female literacy as explanatory variables. In this case, the coefficients on male literacy become negative and insignificant, while the coefficients on female literacy remain positive and highly significant. From an econometric point of view, this further indicates that the effect of investment in the literacy of women on growth is far more robust than the effect of investment in the literacy of men.[15] Note as well that, since our regressions control for the fertility rate, the estimated effect of women literacy on growth is independent of the impact of lower fertility that may result from investment in women's education.[16]

Different explanations could potentially account for the greater effect of investment in women's literacy, as opposed to men literacy. First, to the extent that there were initially social barriers to the education of women, investment in the literacy of women may have been provided to relatively high ability individuals. The more able women were more likely to overcome barriers to education and labor market participation. Thus, there could have been a *selection effect* through which new human capital was combined with

[15] The results of regressions of GDP per capita using the proportion of men and women that achieved at least level 4 on the literacy tests as human capital measures can be found in Coulombe, Tremblay and Marchand (2004). In both cases, the estimated effect of human capital on GDP per capita is much weaker than that estimated from average literacy scores. Interestingly, the share of women that achieved at least level 4 is also found to have a greater impact on growth than the share of men.

[16] The results of a robustness analysis in which estimations were repeated with the same set of independent variables, but in which one country was removed from the sample each time, can be found in Coulombe, Tremblay and Marchand (2004). The results indicate that three variables exhibited strong robustness and are almost not affected by the sample adjustment. These variables are the initial level of GDP per capita or labor productivity, the investment ratio and literacy when it is measured by the scores obtained by women only. The literacy of both men and women combined does not have a significant effect on growth when the UK is excluded from the sample. In this case, the literacy indicator still has a positive sign but its p-value equals 0.12 and 0.30 with GDP per capita and per worker as dependent variables, respectively. In all other cases, however, the literacy of the total population is significant at the 5 per cent level. The results of regressions with the participation rate of women relative to that of men as an additional regressor are also reported. Despite controlling for the effect of women's literacy on their labor market participation, the literacy of women is still found to have a stronger impact on growth than men literacy.

individuals of higher innate potential, on average in the case of women as opposed to men.

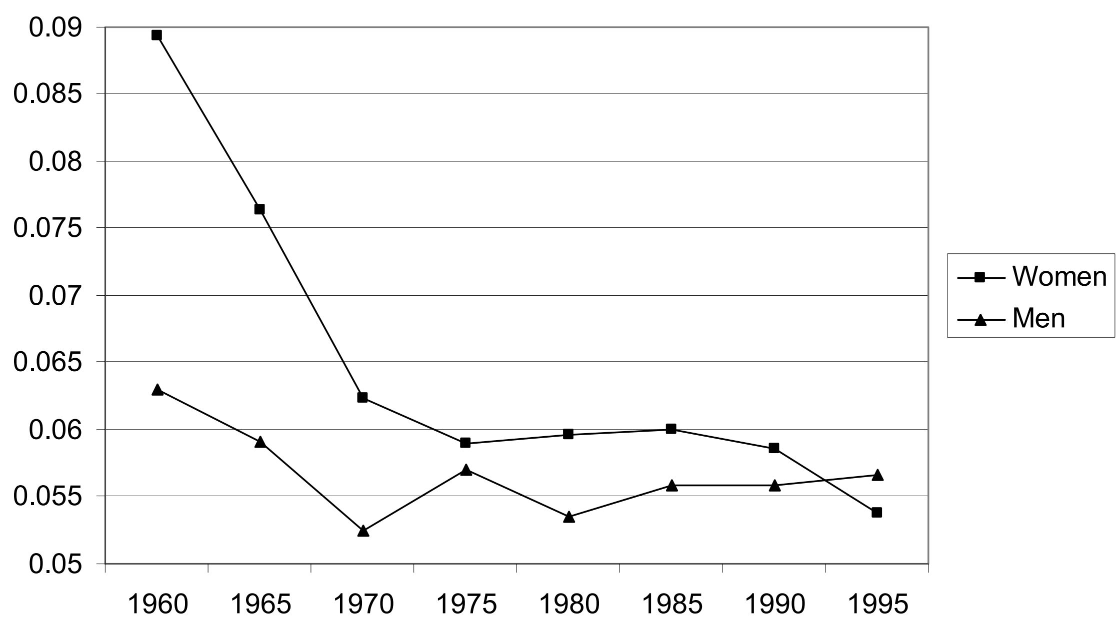
Second, the rate of return on women's human capital investment may have been high because the initial level of literacy was relatively low among women. Because of diminishing returns, the marginal increase in the productivity of labor that results from an increase in human capital is higher for individuals with low initial levels of human capital. So, provided that there were barriers to women's education, investment in women's literacy may have had a greater impact on GDP because of this *marginal return effect*. Note that these first two interpretations concord with Psacharopoulos' (1994) finding on rates of return to education by sexes.

Third, if male and female labor is not perfect substitutes, the relatively low initial literacy level of women may have resulted in a *macroeconomic imbalance effect* between physical and human capital. Because of the complementarity between physical and human capital in the production process, and decreasing marginal returns to the accumulation of each type of capital, the neoclassical growth framework predicts that the economy will grow faster the further away the ratio of human to physical capital is from its steady state level, whether above or below (Barro and Sala-i-Martin, 2004). As for the second explanation, the imbalance between the two capital stocks implies a relatively high marginal return on the one which is relatively scarce and its accumulation induces rapid growth. Therefore, investment in the human capital of women may have had a larger effect on growth than investment in the human capital of men, because women's labor was combined with an unbalanced stock of human and physical capital.

Fourth, men and women may have comparative advantages in certain types of occupations (Galor and Weil, 1996), if for example, men tend to be relatively more productive in manual occupations that require more physical strength. If this is the case, women may have a comparative advantage in occupations that require high levels of human capital. As a result, the optimal stock of human capital would be higher for women than it is for men. Therefore, even if the average levels of human capital were initially equal for men and women, because of this *comparative advantage effect*, we should expect higher macroeconomic returns from investment in the human capital of women and the resulting reallocation of labor across different types of occupations.[17]

Fifth, the precision of the estimation of the impact of human capital variables on growth (and to some extent robustness) depend on the time series and cross-sectional variations of the human capital variables. As shown by Figure 2, there is more variation across countries in women's literacy scores than for men at the beginning of the sample and the cross-sectional variation of the two indicators is roughly the same at the end of the sample. This *statistical effect*, illustrated by the larger sigma-convergence of the female indicator, might by itself account for the measured gender-gap effect. This point is even more important given that the countries that have experienced the most notable catch-up toward the OECD mean during the period under study, namely Greece, Portugal and Spain, are not in the sample currently under study.

Figure 2: Standard Deviation of the Logarithm of Average Literacy Scores Relative to the Cross-Section Mean



[17] Note that, in cases where employment growth is concentrated in knowledge and information intense jobs, this effect would increase the relative importance of female skill levels on growth.

Finally, women's literacy could also capture the effects of omitted variables such as the level of social infrastructure (Hall and Jones, 1999) and social development of a country. Social infrastructure is a concept that is very hard to measure directly and it has not yet been entered as independent variables in cross-country growth regressions. In their cross-country growth accounting approach, Hall and Jones (1999) use social infrastructure to account for the large differences in the Solow residual across developed and less-developed countries. They argue that the level of social infrastructure across countries is mainly determined by history, location, and language. In keeping with this argument it is possible to interpret the strong and robust effect of female literacy in our study by arguing that female literacy (compared to male) is also a determinant of social infrastructure. It will be interesting in further research to explore this hypothesis by using literacy score data in Hall and Jones' growth accounting approach.

4.6 Alternative literacy scale

The use of literacy test scores as indicators of cross-country relative human capital investment in the preceding econometric analysis is based on the assumption that the 0 to 500 scale used to measure test scores is an absolute scale. Under this assumption, a zero score in the proficiency scale is an indication of zero investment in human capital. In order to briefly examine whether the general direction of the results is affected by the use of an alternative scale, we have simply redefine the original scale by assuming that a score 100 is the absolute zero. Under this assumption, a score of 100 is an indication of zero investment in human capital.

Comparing regressions results under the basic and the alternative scales indicates that the point estimates of the literacy variable are smaller with the new scale, decreasing from 0.094 to 0.058 for women literacy and from 0.058 to 0.38 for men literacy. This is not surprising given that the alternative scale increases the cross-section and time series variances of the literacy variable. Furthermore, for both the women and men literacy variables, the t-statistics increases marginally with the alternative scale. This exercise illustrates two points: first, the long-run elasticities estimated for the literacy variable have to be interpreted in the context of the specific scale used to report literacy test scores, and second, the significance of the effect of literacy investment on growth could be marginally improved with an appropriate rescaling of the test scores given that a score zero is impossible to obtain. More work along this line is needed in future research.

5. Conclusions

Recently available comparable cross-country data on literacy skills will most certainly offer great possibilities for understanding the relation between human capital and growth in the future. Literacy tests scores are direct measures of the quality of human capital and are likely to capture more accurately the sources of variance in productive human capital across countries than schooling data. However, in contrast to schooling data, these measures are not yet available over long periods of time, which would seem to imply that their use in the empirical analysis of long-run growth would have to be postponed for a number of years, if not decades. In order to circumvent this problem, we construct synthetic time-series of human capital investment indicators by exploiting the demographic profile of literacy test scores, which allows to extract the information about long-run economic growth contained in a single cross-section of data on literacy skills. Hence, part of our purpose is to make a methodological contribution to the measurement of human capital.

The key result of our analysis is that our synthetic measures of human capital are found to contain more information about the relative growth of fourteen OECD countries than schooling data. In our view, this may reflect the fact that literacy test scores are more direct and accurate measures of human capital than schooling data, as well as being more comparable across countries and across time. In the process, our analysis indicates that investment in human capital does matter for the relative growth of developed countries, in contrast to most previous findings in the economic growth literature.

The distribution of human capital is also found to matter for the long-run relative well-being of nations. First, the positive effect of human capital on growth estimated from average test scores over the entire population is much stronger than that estimated from the percentage of the population that achieved very high scores of literacy. Secondly, our results indicate that investment in the human capital of women is much more important for growth than investment in the human capital of men.

There are two important limitations in our analysis. First, deriving measures of past investment in the human capital of an age-cohort from literacy tests taken later on in their life provides only an imperfect measure of the skills they had when they entered the labor force. In particular, the indicators are distorted by the migration process that occurred over the period and by learning and human capital depreciation that take place over the course of individuals' active life in the labor market.

Secondly, some caution is required in modeling the effect of human capital investment on the growth of open economies. In the open economy neoclassical growth framework with perfect capital mobility for the financing of physical capital but imperfect mobility for the financing of human capital, Barro, Mankiw and Sala-i-Martin (1995) show that the convergence of human capital is the driving force of the convergence of GDP per capita during the transition process toward the steady-state. In this context, the initial level of human capital may be seen as a proxy for the initial level of GDP per capita. As pointed out by Coulombe and Tremblay (2001) and Coulombe (2001), it may therefore be inappropriate to include both the initial level of GDP per capita and human capital as explanatory variables. To the extent that financial capital is imperfectly mobile, as may have been the case between WWII and the 1970s, Barro and Sala-i-Martin (2004) argue that the positive effect of human capital on growth may be capturing an imbalance in the relative stocks of human and physical capital. Such an imbalance may have characterized several OECD countries in the 1950s and 1960s where WWII destroyed primarily physical capital. However, as we move away from the transition period following WWII, the role of human capital investment in growth may need to be modeled differently, from an empirical perspective.

Our analysis is an initial attempt to exploit synthetic time-series data based on direct measures of skills to estimate the effect of human capital accumulation on growth, as opposed to the traditional approach based on schooling data. In order to shed additional light on the relative merits of the two types of human capital measures, it may be interesting in future research to compare the performance of human capital indicators based on literacy test scores with those based on schooling data in the empirical analysis of growth for sub-national economies across which educational systems are likely to be more comparable than across countries. Doing so may provide some indication of whether literacy test scores are in fact better measures of the productive human capital of an economy, or if they are simply more comparable across countries.

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TABLE 1: Conditional Convergence of GDP per Capita, 1960-1995

Human capital investment measured by average test scores of the population aged 17-25

Dependent variable : Log difference of GDP per capita				
Independent variables	**Literacy**	**Prose**	**Quantitative**	**Document**
Initial GDP	-0.047 [a]	-0.048 [a]	-0.048 [a]	-0.046 [a]
	(0.012)	(0.012)	(0.012)	(0.012)
Literacy	0.085 [b]	0.083 [b]	0.083 [b]	0.084 [b]
	(0.034)	(0.032)	(0.035)	(0.035)
Investment rate	0.046 [a]	0.048 [a]	0.044 [a]	0.046 [a]
	(0.008)	(0.009)	(0.008)	(0.008)
Fertility rate	-0.012	-0.012	-0.012	-0.013 [c]
	(0.008)	(0.008)	(0.008)	(0.008)
R^2	0.52	0.53	0.52	0.53
# of observations	95	95	95	95
Implied (α; η)	(0.26; 0.48)	(0.27; 0.46)	(0.25; 0.47)	(0.26; 0.48)

Notes applying to all tables: The estimation method is IWTSLS-IV, unless otherwise stated; The regressions include country fixed effects; White heteroskedasticity standard errors are shown in parentheses below the estimated coefficients; For IWTSLS-IV regressions, the values reported for the R^2 are those of the corresponding IFGLS regressions; a: significant at 1% level; b: at 5% level; c: at 10% level; Instruments used for the IWTSLS-IV estimations are initial GDP per capita of the previous period and the lagged values of the investment rate, of the fertility rate and of the de la Fuente and Doménech average schooling years variable; No significant serial correlation in all regressions; For regressions with GDP per worker as independent variable, the sample excludes Germany; GDP per capita is not available for Germany before 1970; The openness variable is not available for Finland before 1970.

TABLE 2: Conditional Convergence of GDP per Capita and GDP per Worker, 1960-1995

Human capital investment measured by average test scores of the population aged 17-25

Dependent variable : Log difference of GDP per capita				
Independent variables	**Literacy**	**Prose**	**Quantitative**	**Document**
Initial GDP	-0.060 [a]	-0.061 [a]	-0.062 [a]	-0.057 [a]
	(0.012)	(0.012)	(0.012)	(0.012)
Literacy	0.087 [b]	0.087 [a]	0.084 [b]	0.081 [b]
	(0.034)	(0.032)	(0.034)	(0.036)
Investment rate	0.036 [a]	0.039 [a]	0.033 [a]	0.037 [a]
	(0.009)	(0.009)	(0.008)	(0.009)
Fertility rate	-0.016 [c]	-0.016 [c]	-0.017 [c]	-0.017 [c]
	(0.009)	(0.008)	(0.009)	(0.009)
Openness ratio	0.019 [b]	0.019 [b]	0.021 [b]	0.018 [b]
	(0.009)	(0.009)	(0.008)	(0.009)
R^2	0.56	0.57	0.57	0.55
# of observations	93	93	93	93
Elasticities (K; H)	(0.60; 1.45)	(0.64; 1.43)	(0.53; 1.35)	(0.65; 1.42)

Dependent variable : Log difference of GDP per worker				
Initial GDP	-0.046 [a]	-0.048 [a]	-0.045 [a]	-0.044 [a]
	(0.010)	(0.010)	(0.010)	(0.010)
Literacy	0.095 [b]	0.101 [a]	0.079 [b]	0.095 [b]
	(0.037)	(0.036)	(0.036)	(0.038)
Investment rate	0.025 [a]	0.028 [a]	0.021 [b]	0.025 [a]
	(0.009)	(0.009)	(0.009)	(0.009)
Fertility rate	-0.005	-0.005	-0.004	-0.005
	(0.008)	(0.008)	(0.009)	(0.008)
Openness ratio	0.038 [a]	0.038 [a]	0.038 [a]	0.038 [a]
	(0.006)	(0.006)	(0.006)	(0.006)
R^2	0.66	0.66	0.66	0.66
# of observations	89	89	89	89
Elasticities (K; H)	(0.54; 2.07)	(0.58; 2.10)	(0.47; 1.76)	(0.57; 2.16)

TABLE 3: Conditional Convergence of GDP per Capita and GDP per Worker, 1960-1995

Average years of schooling of the population aged 25 and over taken from the de la Fuente and Doménech data set and literacy measured by average test scores of the population aged 17-25

Dependent variable :	**Log difference of GDP per capita**			**Log difference of GDP per worker**		
Independent variables	**IWTSLS-IV**	**IFGLS**		**IWTSLS-IV**	**IFGLS**	
Initial GDP	-0.067 [a]	-0.076 [a]	-0.068 [a]	-0.033 [a]	-0.037 [b]	-0.041 [a]
	(0.013)	(0.014)	(0.014)	(0.012)	(0.014)	(0.012)
Average years of schooling	0.040 (0.029)	0.057 [c] (0.029)	0.019 (0.034)	-0.030 (0.036)	-0.011 (0.039)	-0.057 (0.035)
Literacy			0.085 [b]			0.146 [a]
			(0.040)			(0.035)
Investment rate	0.030 [a]	0.032 [a]	0.038 [a]	0.013	0.024 [b]	0.033 [a]
	(0.008)	(0.009)	(0.008)	(0.009)	(0.010)	(0.008)
Fertility rate	-0.018 [c]	-0.015	-0.016	-0.007	-0.006	0.004
	(0.009)	(0.010)	(0.010)	(0.009)	(0.009)	(0.009)
Openness ratio	0.017 [b]	0.018 [b]	0.021 [a]	0.030 [a]	0.031 [a]	0.033 [a]
	(0.009)	(0.007)	(0.007)	(0.008)	(0.009)	(0.005)
R^2		0.54	0.56		0.59	0.67
# of observations	93	95	95	89	90	90

TABLE 4: Conditional Convergence of GDP per Capita, 1960-1995

Human capital investment measured by the share of the population aged 17-25 that achieved at least level 4

Dependent variable : Log difference of GDP per capita			
Independent variables	**Prose**	**Quantitative**	**Document**
Initial GDP	-0.065 [a]	-0.061 [a]	-0.060 [a]
	(0.012)	(0.012)	(0.012)
Literacy	0.008 [b]	0.005	0.004
	(0.003)	(0.004)	(0.004)
Investment rate	0.035 [a]	0.024 [a]	0.028 [a]
	(0.009)	(0.008)	(0.008)
Fertility rate	-0.015 [c]	-0.017 [c]	-0.017 [c]
	(0.009)	(0.009)	(0.009)
Openness ratio	0.021 [b]	0.020 [b]	0.017 [c]
	(0.008)	(0.009)	(0.009)
R^2	0.56	0.54	0.53
# of observations	93	93	93

TABLE 5: Conditional Convergence of GDP per Capita and GDP per Worker, 1960-1995

Human capital investment measured by average test scores of men and women aged 17-25

Dependent variable:	**Log difference of GDP per capita**			**Log difference of GDP per worker**		
Independent variables						
Initial GDP	-0.052 [a]	-0.073 [a]	-0.067 [a]	-0.038 [a]	-0.055 [a]	-0.062 [a]
	(0.012)	(0.012)	(0.013)	(0.011)	(0.011)	(0.012)
Men Literacy	0.058 [c]		-0.004	0.068 [b]		-0.006
	(0.031)		(0.039)	(0.033)		(0.039)
Women Literacy		0.094 [a]	0.095 [b]		0.099 [a]	0.123 [a]
		(0.032)	(0.041)		(0.034)	(0.043)
Investment rate	0.034 [a]	0.037 [a]	0.044 [a]	0.023 [b]	0.023 [a]	0.032 [a]
	(0.008)	(0.008)	(0.008)	(0.009)	(0.009)	(0.008)
Fertility rate	-0.017 [b]	-0.017 [b]	-0.021 [b]	-0.008	-0.000	0.003
	(0.009)	(0.008)	(0.008)	(0.009)	(0.008)	(0.008)
Openness ratio	0.017 [b]	0.020 [b]	0.014	0.038 [a]	0.039 [a]	0.036 [a]
	(0.009)	(0.008)	(0.010)	(0.006)	(0.007)	(0.007)
R^2	0.55	0.57	0.57	0.67	0.65	0.65
# of observations	93	93	93	89	89	89

Note: For comparison purposes, we have used in the regressions reported in the third and last columns, the lagged values of men and women literacy as instruments.

TABLE A.1: Average Literacy Scores of Individuals Aged 17-25

	Belgium	Canada	Switzer-land	Germany	Denmark	Finland	UK	Ireland	Italy	Nether-lands	Norway	New-Zealand	Sweden	US
							POPULATION							
1960	248.9	255.2	261.0	277.2	271.1	266.8	246.4	238.8	220.0	267.1	280.3	261.9	296.0	270.1
1965	266.1	271.8	266.2	285.6	283.2	277.6	262.2	249.0	230.1	277.6	289.0	268.6	300.7	273.9
1970	273.9	284.4	260.6	286.5	291.9	285.2	271.2	259.9	244.9	282.0	294.9	276.1	302.8	279.0
1975	275.2	292.6	263.1	287.6	296.3	292.8	273.9	268.0	246.4	287.0	298.2	277.4	305.4	280.8
1980	286.4	293.5	274.3	289.9	297.7	301.0	274.7	269.4	250.6	294.4	300.3	278.4	310.8	279.1
1985	293.5	288.0	281.7	291.8	300.1	305.6	276.0	269.1	258.8	297.6	304.1	274.2	316.7	274.5
1990	297.6	285.5	287.0	294.0	302.5	309.2	274.5	271.7	270.9	298.7	308.6	275.3	315.4	267.0
1995	298.0	288.0	290.8	290.2	295.8	308.8	273.5	274.3	269.9	295.0	302.8	275.6	312.2	262.8
							WOMEN							
1960	235.3	254.9	255.7	273.5	266.0	266.8	240.9	234.9	202.9	259.9	278.0	260.2	287.7	270.9
1965	258.2	276.8	257.0	279.8	277.4	277.9	255.6	248.0	218.5	270.4	288.0	266.2	299.4	268.8
1970	267.7	291.2	256.3	283.3	286.4	285.4	265.0	257.4	238.3	275.6	290.8	272.0	301.4	276.8
1975	273.2	293.2	264.1	284.9	291.1	294.4	267.9	267.6	242.4	284.5	293.8	273.6	304.3	280.1
1980	287.6	295.6	272.4	289.2	294.7	304.0	269.4	268.1	248.3	294.6	300.4	276.1	308.3	280.3
1985	292.4	288.7	276.6	289.9	298.0	307.5	269.4	267.5	254.9	296.1	305.8	273.1	313.3	279.5
1990	299.7	277.1	282.5	291.4	300.5	314.5	270.4	274.2	266.8	297.6	309.9	277.0	312.3	269.0
1995	297.2	283.6	291.8	286.9	296.8	312.6	272.4	276.7	269.8	293.2	303.3	277.5	308.8	262.4
							MEN							
1960	265.7	255.5	266.9	280.7	276.5	266.9	252.3	243.2	238.8	274.1	282.1	263.5	304.8	269.1
1965	273.7	266.3	277.3	291.3	288.8	277.3	269.4	250.0	242.6	284.6	289.8	271.0	302.0	280.3
1970	280.2	276.3	265.2	290.1	297.2	284.9	277.9	262.2	251.3	288.0	298.5	280.2	304.0	281.4
1975	277.1	292.1	262.0	290.3	301.3	291.2	279.9	268.4	250.1	289.4	302.5	281.4	306.5	281.5
1980	285.3	291.2	276.4	290.5	300.6	298.1	280.1	270.8	252.7	294.2	300.3	281.0	313.3	277.8
1985	294.6	287.4	286.0	293.7	302.2	303.7	282.7	270.7	262.6	299.0	302.5	275.3	319.9	268.5
1990	295.5	293.3	290.6	296.6	304.4	304.3	278.5	269.3	275.5	299.8	307.3	273.7	318.7	264.6
1995	300.9	292.3	290.0	292.8	294.8	305.2	274.5	272.0	270.0	296.6	302.3	273.6	315.4	263.3

TABLE A.2: Average Prose Scores of Individuals Aged 17-25

	Belgium	Canada	Switzer-land	Germany	Denmark	Finland	UK	Ireland	Italy	Nether-lands	Norway	New-Zealand	Sweden	US
							POPULATION							
1960	243.3	257.6	252.9	267.0	259.8	265.8	245.3	241.6	217.9	263.0	273.5	268.0	290.6	274.0
1965	260.4	273.3	259.9	276.7	270.0	276.3	261.3	250.5	228.8	274.1	281.1	272.9	295.7	276.3
1970	269.3	285.5	253.5	277.2	277.7	284.2	270.4	261.8	245.3	278.8	287.5	279.5	298.7	280.8
1975	271.0	290.8	256.2	278.8	281.7	292.4	272.6	270.0	246.8	284.3	292.5	280.5	302.1	282.5
1980	280.3	289.9	267.3	282.0	282.4	301.8	273.4	271.8	251.1	291.4	294.0	281.0	307.7	280.0
1985	286.7	284.7	274.1	283.4	284.4	307.3	275.0	271.5	260.4	295.1	297.9	276.3	313.5	274.7
1990	290.9	284.3	279.8	284.9	287.3	311.4	274.4	274.6	274.2	296.9	303.4	277.5	314.0	267.0
1995	292.7	287.1	284.0	282.5	282.3	314.0	273.9	277.6	274.4	292.1	300.0	278.1	312.7	263.2
							WOMEN							
1960	233.7	264.4	251.0	265.1	259.9	270.2	244.3	242.2	205.8	260.9	275.9	271.7	287.2	279.3
1965	257.6	284.3	253.9	273.1	270.1	281.2	259.7	254.0	222.1	272.2	284.9	275.9	300.1	276.5
1970	267.5	296.0	251.0	276.4	277.8	288.7	269.1	262.9	244.3	277.1	289.4	281.3	303.2	283.5
1975	273.0	292.9	258.8	278.3	282.5	298.3	272.6	273.4	248.2	286.2	294.7	282.3	306.3	286.4
1980	285.5	297.3	268.4	284.4	284.8	309.2	274.2	274.7	255.1	296.8	300.2	284.1	310.9	285.0
1985	288.7	290.3	271.7	285.3	287.6	314.0	274.2	274.5	262.4	298.1	304.5	280.0	314.7	282.4
1990	296.3	280.9	277.6	286.4	290.5	321.4	275.3	280.6	275.1	300.4	309.6	284.1	314.4	271.9
1995	294.7	287.7	288.1	282.7	287.3	322.6	277.2	283.7	278.7	295.4	304.9	285.8	313.3	265.5
							MEN							
1960	255.2	252.4	254.9	268.9	259.7	260.8	246.4	240.9	231.3	265.1	271.5	264.4	294.2	267.5
1965	263.0	261.3	267.1	280.2	269.9	271.5	263.2	247.2	236.0	276.0	277.7	269.9	291.4	276.1
1970	271.2	272.8	256.1	278.1	277.6	279.8	271.7	260.8	246.1	280.3	285.8	277.8	294.8	278.0
1975	269.0	288.6	253.5	279.3	281.0	286.7	272.5	266.6	245.4	282.5	290.5	278.6	297.9	278.4
1980	275.8	282.1	266.1	279.6	280.0	294.3	272.5	268.6	247.5	286.5	288.2	277.5	304.5	274.6
1985	284.8	278.9	276.2	281.3	281.3	300.8	275.8	268.4	258.5	292.1	291.9	272.3	312.3	265.2
1990	285.6	287.5	281.6	283.4	284.2	302.3	273.5	268.7	273.2	293.7	297.4	270.8	313.6	261.1
1995	293.0	286.6	280.9	282.3	277.5	305.7	270.7	271.7	270.2	289.0	295.2	270.1	312.0	260.8

TABLE A.3: Average Quantitative Scores of Individuals Aged 17-25

	Belgium	Canada	Switzer-land	Germany	Denmark	Finland	UK	Ireland	Italy	Nether-lands	Norway	New-Zealand	Sweden	US
							POPULATION							
1960	252.5	256.2	271.7	288.8	282.6	270.0	251.2	241.2	227.5	272.8	287.4	261.4	301.0	273.1
1965	271.1	270.8	275.2	296.4	294.7	279.9	265.7	251.8	237.4	281.4	295.4	268.7	305.2	277.7
1970	279.5	288.9	270.4	295.9	302.8	286.5	274.3	262.7	250.8	284.8	299.6	276.8	306.3	283.1
1975	279.9	294.4	271.8	295.9	305.9	292.3	276.6	270.1	251.7	288.8	301.0	277.3	307.7	284.7
1980	291.6	295.6	281.8	297.1	305.8	297.6	276.7	270.8	254.4	296.3	302.7	277.6	312.1	283.3
1985	299.9	288.9	288.2	299.1	307.4	299.5	276.9	269.9	261.6	298.4	305.1	273.0	316.7	277.4
1990	303.3	284.0	291.5	301.2	308.2	301.4	273.3	271.5	271.6	297.9	307.7	272.7	313.8	267.5
1995	300.6	283.2	292.9	295.4	300.3	298.1	268.8	274.0	268.3	292.9	299.1	272.2	309.3	262.1
							WOMEN							
1960	235.8	251.9	263.0	284.3	273.9	265.3	241.4	232.2	207.0	261.0	282.0	255.1	289.0	269.5
1965	258.7	272.7	262.8	289.8	284.6	275.4	254.4	246.7	222.6	269.5	291.0	261.1	299.7	267.9
1970	267.3	294.8	263.3	290.5	293.0	282.6	263.7	256.6	240.4	273.8	291.8	266.6	300.5	276.6
1975	272.1	293.0	270.4	291.2	295.9	289.6	265.7	266.2	244.6	282.1	292.6	268.7	301.5	279.4
1980	287.8	294.9	277.7	293.7	298.3	295.9	265.9	266.2	248.4	292.0	298.5	270.7	304.9	280.4
1985	295.8	286.9	280.7	294.0	301.0	297.6	265.2	265.0	254.0	292.6	303.4	267.7	310.0	279.2
1990	303.2	273.4	285.7	295.5	302.5	302.8	265.0	271.3	263.8	292.0	305.4	269.8	307.7	265.5
1995	297.2	274.6	292.0	289.1	298.2	297.2	264.2	273.8	264.7	286.4	296.2	269.3	302.7	257.5
							MEN							
1960	273.4	259.6	281.1	293.3	292.1	275.4	261.5	250.8	250.3	284.3	291.7	267.5	313.8	277.6
1965	283.0	268.7	290.0	302.8	304.5	284.3	278.1	256.6	253.5	293.1	299.3	276.6	310.6	290.1
1970	291.9	281.8	278.0	301.6	312.2	290.3	285.7	268.3	261.0	294.9	306.7	286.9	311.5	290.1
1975	287.2	295.8	273.3	300.6	315.5	294.9	287.6	273.9	258.5	295.2	309.1	286.4	313.7	290.2
1980	295.0	296.3	286.3	300.6	313.0	299.3	287.6	276.0	259.9	300.2	306.6	285.3	319.2	286.5
1985	303.7	290.9	294.5	304.5	313.7	301.4	289.0	275.0	269.1	304.0	306.5	278.6	323.3	275.1
1990	303.4	293.9	296.2	306.8	313.7	300.2	281.5	271.6	280.1	303.3	309.9	275.6	320.0	270.0
1995	306.2	291.4	293.5	300.5	302.3	298.9	273.2	274.2	271.7	299.1	302.0	275.3	315.5	266.7

TABLE A.4: Average Document Scores of Individuals Aged 17-25

	Belgium	Canada	Switzer-land	Germany	Denmark	Finland	UK	Ireland	Italy	Nether-lands	Norway	New-Zealand	Sweden	US
							POPULATION							
1960	250.7	251.8	258.6	275.7	270.8	264.7	242.8	233.8	214.5	265.6	280.0	256.2	296.3	263.2
1965	266.9	271.3	263.6	283.7	284.9	276.6	259.5	244.8	224.0	277.2	290.4	264.1	301.3	267.5
1970	272.9	278.8	258.0	286.5	295.2	284.8	269.1	255.2	238.6	282.5	297.5	272.2	303.2	273.1
1975	274.9	292.8	261.2	288.1	301.2	293.7	272.4	264.0	240.7	287.9	301.2	274.4	306.4	275.2
1980	287.3	294.9	273.8	290.5	305.0	303.8	274.1	265.6	246.2	295.5	304.3	276.6	312.7	273.9
1985	294.0	290.6	282.7	292.8	308.6	309.9	276.0	265.8	254.4	299.3	309.2	273.2	319.8	271.5
1990	298.6	288.2	289.5	296.0	311.9	314.7	275.8	269.1	267.1	301.4	314.6	275.8	318.5	266.5
1995	300.6	293.9	295.5	292.7	304.8	314.4	277.8	271.4	267.1	299.9	309.3	276.4	314.6	263.3
							WOMEN							
1960	236.5	248.3	253.1	271.2	264.3	264.8	237.0	230.2	196.0	258.0	276.2	253.7	286.8	264.0
1965	258.4	273.4	254.3	276.4	277.4	277.0	252.6	243.3	210.8	269.5	288.1	261.7	298.6	261.9
1970	268.3	282.7	254.7	282.8	288.3	284.9	262.2	252.7	230.3	275.7	291.2	268.2	300.5	270.3
1975	274.6	293.6	263.0	285.2	294.9	295.3	265.3	263.3	234.6	285.1	294.2	269.9	305.0	274.5
1980	289.6	294.6	271.2	289.6	301.0	306.9	268.1	263.4	241.3	295.1	302.5	273.4	309.2	275.4
1985	292.7	288.8	277.4	290.5	305.6	311.0	268.8	262.9	248.2	297.7	309.4	271.7	315.2	276.8
1990	299.7	277.0	284.2	292.3	308.5	319.4	271.0	270.7	261.4	300.3	314.8	277.0	314.7	269.7
1995	299.7	288.5	295.4	289.0	304.9	318.0	275.7	272.8	266.0	297.8	308.8	277.6	310.4	264.2
							MEN							
1960	268.5	254.6	264.7	280.0	277.8	264.5	249.0	237.7	234.9	273.0	283.1	258.5	306.4	262.4
1965	275.0	269.0	274.8	290.9	292.0	276.2	267.0	246.2	238.3	284.8	292.5	266.6	304.0	274.6
1970	277.4	274.2	261.7	290.5	301.8	284.8	276.4	257.5	246.8	288.9	303.2	276.1	305.6	276.1
1975	275.2	291.9	259.2	291.0	307.4	292.1	279.6	264.8	246.3	290.5	307.9	279.2	307.7	275.9
1980	285.2	295.2	276.7	291.4	308.8	300.6	280.1	267.9	250.7	295.8	306.0	280.2	316.1	272.3
1985	295.3	292.4	287.3	295.4	311.6	308.9	283.3	268.8	260.4	300.8	309.0	274.9	324.3	265.1
1990	297.5	298.6	293.9	299.6	315.2	310.3	280.5	267.6	273.4	302.4	314.4	274.6	322.5	262.7
1995	303.6	299.0	295.6	295.7	304.8	310.9	279.8	270.0	268.1	301.8	309.8	275.3	318.6	262.4