Human Capital Quality and Economic Growth

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Abstract. The estimation of the relationship between education and economic growth is marked by contradictions. These contradictions underline the lack of precision characterising indicators of human capital. This paper uses new indicators based on a pool of international surveys concerning pupil assessment. These indicators can be viewed as proxies of quality of schooling. Thus, our new databases, the first in cross section and the second in panel, make it possible to confirm or not the positive relationship between education and growth. Taking into account the endogeneity of education, we measure a positive effect of schooling quality and economic growth between 1960 and 2000. The contribution of education to growth therefore appears significant, if we take into account the qualitative dimension of the human capital. To our knowledge, this is the first paper to take into account for the quality of schooling in a panel dimension.

Keywords : Education Quality, Human Capital, Growth, Development.

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1. Introduction

The study of the determinants of economic growth has been one of the most important fields of research in economics since the mid 1980s. This field of research was spurred by the endogenous growth literature pioneered by the analysis of Paul Romer (1986) and Lucas (1988). Moreover, an important contribution came from the growth-empirics approach that began with the testing of the neoclassical convergence hypothesis (Baumol, 1986; Barro, 1991; Barro and Salt-I-Martin, 1992; Mankiw, Romer, and Weil, 1992). It is also necessary to underline the important contribution relating to the development of comparable cross-country data on GDP, productivity and human capital indicators (Summers and Heston, 1988; Barro and Lee, 1993, 1996, 2001).

Nevertheless, Lant Pritchett underlined the controversies surrounding the relationship between education and growth (Pritchett, 2001). Indeed, in spite of the large number of recent empirical studies carried out on data of international comparisons, the assumption of a clear and positive relationship between the investment in human capital and economic growth has been largely called into question. Let us note that in this paper, we consider education only as a component of human capital. Certain international comparative studies have shown that many educational variables are factors determining the growth of per capita GDP in a country (Barro, 1991; Mankiw *et al.*, 1992). However, lack of data have led to serious limitations: educational variables such as schooling rates or the average number of school years are vague indicators of the measurement of human capital relating to education. Pritchett (2001) even wonders “where has all education gone?”.

Pritchett's paper suggests three main explanations to understand why the most robust econometric analyses do not make it possible to prove a stable and positive relationship between human capital and economic growth:

- Individual wage increases can lead to a slowdown in the country if the new graduates move in mass towards public sectors;
- If, in spite of an increase in the educated population, the private sector does not need new skilled workers, an unexpected decrease in the rate of return of education can occur ex post. Thus, the contribution made by individual profit will be smaller than the rate of return ex ante would have predicted;
- The quality of education may be so low that it does not produce the necessary skills to lead to economic growth.

The main thrust of by this paper takes into account this last assumption. According to the analysis of Hanushek and Kimko (2000), we start from the idea that one year of education in country *i* does not confer the same rate of return as one year of education in country *j*. Thus, the studies which take into account only quantitative indicators of education will be skewed, owing to the fact that they regard human capital as a homogeneous factor of production.

In this paper, we elaborate a new methodology producing qualitative indicators of human capital (*QIHC*) for a greater number of countries than those included in the pioneering studies in this field (Hanushek and Kimko, 2000; Barro, 2001). Using a specific methodology, we compiled the results of countries in the international investigations into the assets of the pupils for each skill (mathematics, sciences and reading) between 1960 and 2005. We obtained two databases. The first is a cross-country database which includes approximately 120 countries and three different skills (mathematics, science and reading). The second database is a panel database and includes data from 1960 to 2005 for a broad number of countries. The principal contribution of this paper is the inclusion of new countries (a majority of the countries with middle or low incomes), whereas preceding studies were focused almost exclusively on high income countries. For example, our database includes 27 countries of sub-Saharan Africa, where other databases often neglect this continent in their analyses.

Section 2 presents an overview of the principal studies undertaken on the relationship between education and economic growth. In section 3, we detail the data sources and general methodology used to obtain our database on the qualitative indicators of human capital. Section 4 estimates the contribution of the quality of education to economic growth. Lastly, section 5 concludes our analysis.

2. Review of literature

This section draws up a short review of the literature on the education-growth relationship, based essentially on the qualitative analyses of this relationship. For a more complete review, see for example Aghion and Howitt (1998) or more recently Hanushek and Wößmann (2007).

2.1. Initial models measuring education as a flow

The idea according to which education contributes to growth constitutes at once the origin and the result of the theory of human capital. Theodore W. Schultz (1961) observes that education explains most of the Total Factor Productivity, that portion of growth that neither the physical capital nor the volume of labour manages to predict. Macroeconomic models estimated by accounting methods, then econometrics, take as a starting point the introduction of human capital into an aggregate production function, in addition to physical capital or the quantity of labour.

One can distinguish two approaches in terms of education (Aghion and Howitt, 1998):

- Lucas (1988) shows that there are two sources of human capital accumulation: education and learning by doing. This furthers the analysis by Becker (1964) in which growth is primarily determined by the accumulation of human capital (in terms of *flows*). This analysis is thus in accordance with those of Mankiw, Romer and Weil (1992) and Barro (1990).
- The work of Nelson-Phelps (1966) shows that the stock of human capital is the principal engine of growth and not the difference in rates: the variations in growth between countries are determined by the differences between their *stocks* of human capital and so by their respective capacities to generate technical progress.

The principal difficulty concerns the measurement of human capital. Indeed, in order to introduce human capital as a factor of production, it is necessary to have data in terms of stocks. However, as Mankiw, Romer and Weil (1992) show, one can use flows of investment, with the proviso of introducing a structural model of growth and supposing that these economies are close to their stationary equilibrium. The estimates are carried out on a hundred countries and the explained variable is the per capita GDP growth between 1960 and 1985. The authors measure human capital investment by means of the gross enrolment ratios (GER). Barro makes a distinction between primary and secondary education and retains the value for 1960, while Mankiw, Romer and Weil use an average of the GER of secondary schooling over the time-period studied. The effects are significantly positive (however, they are only significant at 10 % level for the OECD countries studied).

Directly inspired by the arbitration between education and immediate income of the labour force proposed by Becker (1964), Lucas (1988) considers human capital as an assimilation between physical capital and the labour force. Like investment in physical capital, educational investment leads to an increase in a factor of production, namely human capital. This accumulation allows for the creation of direct outputs for those who are best equipped; but its distribution and its concentration must be analysed, because as for physical investment, cases of thresholds or externalities exist which can modify the level and the forms of appropriation of the output.

Thus, one of the lessons of Lucas's work is that to invest in primary education, to choose a "rectangular" approach, i.e. based on mass education, can encourage growth in a country, allowing it to escape the trap of underdevelopment. However, we show below that these specifications have their limitations.

2.2. Current difficulties in proving the relationship between education and growth

The principal limit in Lucas (1988), Barro (1991) and Mankiw *et al.* (1992) is the implicit assumption that education exerts an identical effect on all individuals, as the capital factor does. The marginal product of education can remain indefinitely positive, over the entire population. However, this assimilation of human capital to "traditional" capital seems to contradict the facts.

Another limit is related to the fact of the endogeneity of education. In cross section analysis, there are structural differences between countries (institutional, political...) which can explain the variations in growth and even in the accumulation of human capital. The specifications of authors who measure education in terms of *flows* would then allocate to human capital the effect on income of these intrinsic characteristics.

Lastly, the authors suppose that economies converge towards their standing point and are not very distant from it. For this to be true, the rate of savings would have to be constant over the period 1960-1985, which would amount to supposing that developing countries are precisely not under-developed.

Other authors have tried to directly estimate aggregate production functions, so as to produce robust results with economic assumptions relating to equilibrium. Various authors (Kyriacou , 1991; Lau, Jamison and Louat, 1991; Lau *et al.*, 1991; Barro and Lee, 1994; Nehru *et al.*, 1995) have tried to constitute data on human capital stock allowing international comparisons over a long period. This approach, gravitating around the pioneering article by Nelson and Phelps (1966), was based on these data in *stock*s, better adapted to the theory. Indeed, here the assumption of proximity to stationary equilibrium can be slackened. And if one assumes that the endogeneity of education can be treated in terms of fixed effects (non-observed country characteristics, correlated with education, are essentially invariant over time), the estimate of growth rate directly removes the skew of endogeneity.

In these terms, the study of Pritchett (2001) is a very interesting example. Using two recent cross-national time-series datasets (Barro and Lee, 1994; Nehru *et al.*, 1995), Pritchett estimates the direct estimation of change-on-change regressions. From these estimates of years of schooling of the labour force, he creates a measure of educational capital from the microeconomic specification of earnings used by Mincer (1974). The human capital index is given by :

$$h = \exp(r \times S) - 1 \qquad (1)$$

where h is human capital per worker, r is the return to education (which Pritchett sets at 0.1) and S is the average number of years of schooling taken from Barro and Lee (1994). He then estimates the following cross-section regression:

$$\Delta y_i = \Delta A_i + \alpha \Delta k_i + \beta \Delta h_i + \varepsilon_i \qquad (2)$$

where $y = Y / L$, $k = K / L$ for each country i and Δh stands for growth rate of variable h, over the period 1960-1985. Surprisingly, the estimate of the impact of growth in educational capital on growth in per worker GDP is negative (-0.049) and insignificant (t=1.07). Other studies report similar results (for example, Benhabib and Spiegel, 1994; Islam, 1995).

Thus, when the most robust econometric methods are used, particularly in the correction process for selection bias, it becomes impossible to reveal a positive relationship between human capital and economic growth, whatever the economic specification selected (Gurgand, 2000). The analyses of Pritchett (2001), Benhabib and Spiegel (1994) and Islam (1995) highlight this absence of relationship between growth and education. More surprising, these models show that education acts negatively on aggregate income and sometimes in a very significant way.

Recently, Temple (2001) has revisited Pritchett's results. He estimates the following cross-section regressions :

$$\Delta \log(Y_i) = C_0 + \alpha \Delta \log(K_i) + \beta \Delta f(S_i) + \gamma \Delta lo(L_i) + \Delta \varepsilon_i \qquad (3)$$

where $f(S_i)$ is a function of the number of years of schooling. Temple explores the effects of estimating this production function by assuming different formulations for human (in particular for $f(S_i) = rS_i$ and for $f(S_i) = c_0 + c_1 \log(S_i) + c_2 (1/S_i)$). None of these yielded significant coefficients at standard levels.Temple concludes that "[…] the *aggregate* evidence on education and growth, for a large sample of countries, continues to be clouded with uncertainty".
Some researchers argued that this failure was due to the quality of the education data. Topel (1999), and Krueger and Lindhal (2001) argue that measurement error in the number of years of schooling is a major cause of the apparent lack of significance of ΔS_i in growth regressions. In both papers, the authors report panel data results for the following equation for country i in year t :

$$\Delta \log(Y_{it}) = \pi_1 S_{it-4} + \pi_2 \Delta S_{it} + \pi_3 \log(y_{it-1}) + \Delta \tau_t + \Delta \varepsilon_{it} \qquad (4)$$

where $\Delta \tau_t$ represents a time-specific effect. The years of schooling is taken from Barro and Lee (1996). Topel and Krueger and Lindhal find that in high frequency regressions (i.e. panel data with five year observations) ΔS_i is not significant, while in lower frequency regressions (ten or twenty-year observations) ΔS_i becomes significant. The authors argue that in short periods of time ΔS_i has a low informational content relative to the measurement error and this is why in five-year data regressions the signficance of ΔS_i is rejected. But in longer periods of time true changes in S are more likely to predominate over measurement errors.

But, Soto (2002) underlines that these findings must be looked at with some caution for three reasons. First, he argues that the regressions are not based on a specific growth model and when we use lagged income, it is hard to justify the presence of both the change and the level of schooling simulatenously. Secondly, in almost all the regressions reported, the endogeneity of years of education is completely neglected. This variable is likely to be endogenous since richer countries can afford more spending on education, and hence reach a higher level of education. Krueger and Lindhal try few regressions with instrumental variables methods, but they don't use lagged values of endogenous variables to overcome the measurement error or endogeneity problems. They prefer to estimate regressions with Kyriacou's series as instruments. However, this instrument does not represent a solution to endogeneity since it is itself an endogenous variable. Lastly, Soto argues that ΔS_i is significant only when the change in the stock of physical capital is omitted from the regressions. When Krueger and Lindhal include $\Delta \log(k)$, ΔS_i loses its explanatory power, while physical capital growth gets a coefficient as high as 0.8.

2.3. Taking into account the qualitative dimension of education

As underlined above, Pritchett suggested three main explanations for the difficulty of finding a positive relationship between human capital and growth. One of the explanations proves to be the necessary distinction between quantity and quality in education. Indeed, most studies use strictly quantitative indicators of human capital. Few studies take into account, even partially, the quality of education. We will discuss below of five important studies which tries to take into account the qualitative dimension of education.

Hanushek and Kimko (2000), concerned with finding a better measurement of the quality of human capital, measure it using scores obtained from students participating in international assessments in science and mathematics. Starting from these test scores, they construct a unique (normalised) labour force quality measure for 31 countries covering the period from 1960 to 1990. They computed a quality measure for each country's labour force using the weighted average over all harmonised test scores where each country's weight is calculated as the normalised inverse of its standard error. They then performed a single cross-country regression for the 31 countries over the 1960-1990 period. The authors used the investigations of the IEA (International Association of the Evaluation of Educational Achievement) and of the IEAP (International Assessment of Educational Progress). In total, twenty-six series of educational performances were taken into account (by distinguishing according to age, the field of competence, namely mathematics and sciences, and year). The authors then proceeded to a regression of the average annual growth rate on the initial (1960) per capita income, the quantity of schooling, the average rate of population growth, the quality of the labour force and a constant. Their estimate reveals a negative and significant coefficient on the initial per capita income variable; a positive but insignificant one on the quantity of schooling variable; a positive and highly significant coefficient on the labour force quality variable; and a negative but insignificant coefficient on the rate of population growth. After testing for causality, they conclude that there is a significant and positive causal relationship between the quality of the labour force (in other words better productivity) and the growth rate of the economy.

Another contribution to the field of study which directly includes the measurement of the quality of education in a model of growth is that of Barro (2001). These data come from the same sources as those of Hanushek and Kimko. Barro however builds different indicators according to skill, namely mathematics, sciences and reading. These indicators are available for one period only and are introduced into a panel regression used in a previous article (Barro, 1997). Because of the restricted number of countries for which qualitative indicators of education are available, the sample is smaller and involves only 43 countries. The method of estimate used includes three equations in which the dependent variable is the real growth rate of the GDP per capita in purchasing power parity over the periods 1965-75, 1975-85 and 1985-90. Barro then uses many control variables such as an index of justice (rule-of-law index, an indicator of international trade, an indicator of inflation or fertility, etc). In order to avoid possible problems of endogeneity, the author uses the method of the three-stage least square to solve a model with three simultaneous equations. Barro's results suggest that the quality of education is much more important than the quantity as measured by average secondary and university levels of attainment. In line with Hanushek and Kimko's results, Barro finds that the coefficient on the quantity of schooling variable is positive but insignificant, while that of the quality of schooling variable has a strong and significant predictive power.

Other studies have found very similar results. Lee and Lee (1995) found an effect size similar to Hanushek and Kimko (2000) using data from the 1970-71 First International Science Study on the participating 17 countries, also leaving quantitative measures of education with no significant effect on growth. Extensions of the measure of Hanushek and Kimko (2000) and its imputation in Wößmann (2003) are also used in the cross-country growth regressions by Bosworth and Collins (2003) and in the cross-country industry-level analysis by Ciccone and Papaioannou (2005). Both studies find that educational quality strongly dominates any effect of educational quantity on growth. Lastly, Coulombe, Tremblay, and Marchand (2004) and Coulombe and Tremblay (2006) use test score data from the International Adult Literacy Survey in a panel of 14 OECD countries, confirming the results that the quality measure outperforms quantitative measures of education.

3. Data and methodology

This section describes the nature of the data used to obtain the qualitative indicators of human capital (QIHC). Thereafter, we present the general methodology used to homogenize these data and to use them directly in the regressions.

3.1. Data used

The cognitive levels of pupils can be measured using the results on international investigations into pupil assets. These investigations set up specific procedures to measure qualification levels in mathematics, sciences and reading. The questionnaires were administered to several thousand pupils per country and were at once adapted to the local context and appropriate for international comparison (international standardisation of the tests). Thus, these investigations, insofar as their sampling is adequate, can measure the international variations in pupils' cognitive attainment and thus distinguish differences in quality in the future labour force.

We used results from 7 groups of different international investigations (TIMMS, PIRLS, PISA, SACMEQ, PASEC, LLCE and MLA). The set of investigations used and the principal information relating to them are summarised in appendix 3. For a thorough description of these investigations, see in particular Beaton *et al.* (1999).

It should be noted that the investigations used do not always refer to the same educational level. While certain investigations measure pupils' skills at the secondary level (IEA-TIMSS, PISA, IEA), others are carried out at the primary level (IEA-PIRLS, LLCE, PASEC, SACMEQ, MLA). More generally, the investigations measuring pupils' attainment in the rich countries are those which concentrate on the secondary level, while the other investigations prefer to measure skills at the primary level. Another difference arises from the fact that certain evaluations group pupils by age (PISA), while others group pupils by school level (IEA, LLCE, PASEC, MLA). This difference results in different country classifications according to the extent to which the practice of repeating a school year (which may be considerable in the developing countries) is used. Nevertheless, these limits modify the procedure of re-adjustment little insofar as the majority of countries having taken part in the PISA investigation also participated in the IEA reference investigation.

3.2. Methodology

Our study is in the prolongation of the work of Hanushek and Kimko and that of Barro. In order to improve our understanding of the impact of human capital on economic growth, we used 6 groups of international investigations of pupil attainment. We carried out an adjustment of these investigations to a common scale. The method used takes into account those countries which took part in several investigations simultaneously. By means of these results, we effected an anchoring of the investigations relative to each other. We find in Mingat (2003) a rather similar methodology of anchoring of the data relating to the investigations of pupil assets in sub-Saharan African countries. As a result of these procedures, we obtain qualitative indicators of human capital (*QIHC*) for three fields of competence (mathematics, sciences, reading). Two different databases are available. The first is a cross-country database which relates quality of schooling for 120 countries and for the most recent year. The second database is in panel and includes more than 800 observations for quality of schooling between 1965 and 2005, for secondary and primary schooling and for three different skills (mathematics, science and literacy). In this paper, we only use scores in mathematics and science for secondary level.
In an appendix, we detail the methodology used to build our databases. The usual statistical indicators of the *QIHC* are presented in appendix 2.

4. Model and results

This section draws up the estimates carried out concerning the education-growth relationship. We firstly estimate the education-growth relation with the cross-country database. After controlling for endogeneity, we test the relation with the panel database.

4.1. Education-Growth relationship

To evaluate the contribution of education to economic growth, two main approaches can be declined. The first approach assumes education plays the same role as physical capital in production: the stock of accumulated capital determines the possibilities of production at a

given time. Consequently, the *growth rate* of the economy is affected by the *growth rate* of school attainment (Benhabib and Spiegel, 1994; Pritchett, 2001). The second approach suggests that the activities of research and development (R&D), by accumulating an immaterial stock of ideas and knowledge, make it possible to increase the effectiveness with which it is possible to produce wealth from capital and work (Romer, 1990). By raising the level of education and therefore the number of very qualified workers who can take part in this accumulation of knowledge, the rate of discoveries is increased, and thus the potentialities for growth in the economy. Education can play another role which is to support, not technological innovation, but its adaptation. Nelson and Phelps (1966) very early suggested that the most powerful technologies are adopted and implemented more quickly by those economies richest in human capital. From this viewpoint, it is the *level* of education which raises the *growth rate* of the economy, by accelerating the assimilation of technical progress. Consequently, if a country devotes, in any one year, more resources to education and thus increases its stock of human capital, the result will be an increase in the growth rate of the economy. According to the ideas of Nelson and Phelps, it may be that education also increases the capacity to carry out strictly economic choices, in particular suitable allocation of resources. This second approach thus supposes that the output of education is all the higher as there are major opportunities for technological imitation and adaptation in an unstable universe. In their recent report for the French Council of Economic Analysis, Aghion and Cohen (2004) articulate these two mechanisms by distinguishing economies of imitation from economies of innovation. The first group of economies must invest primarily in the school levels supporting the imitation and implementation of new techniques, that is to say, primary and secondary education. This group includes countries with low and middle incomes. In order to encourage growth, the second group of countries must contribute to technological innovation and have at their disposal an large mass of skilled labour. This justifies a major investment in higher education supporting economic growth. The developed countries belong to this second group of economies.
As shown in section 2, a considerable controversy has emerged in the literature about whether it is the *level* of years of schooling or the *change* in years of schooling which is the more important driver of economic growth. In this paper, we try both effects. Firstly, we will estimate the effect of the *level* of schooling quantity and quality on economic growth. In order to control for potential endogenous biaises, we will further estimate the growth-in-growth regression.

4.2. Results

Firstly, we conduct a pooled time-series cross-section regression. The dependent variable is the growth rate of per capita GDP. In order to avoid for potential mesurement error, the data are averages over ten years and cover the time period 1965-2005. They extend to approximately 108 countries. Since some of the data are not available for all countries or years, the panel data are unbalanced and the number of observations depends on the choice of explanatory variables. To account for time-invariant unobservable heterogeneity potentially correlated with the regressors, a fixed effects specification in used. A dummy for each of the ten-year-periods is also included. All standard errors are estimated robustly. Data sources and general statistics are listed in appendix.

As mentionned in section 3, two databases are available concerning quality of schooling. Despite the fact that using the panel database in panel estimation would be natural, it should be noted that there are very few countries for which we have data for more than two years.

Hence, we will use both databases. In table 1, we include the first database – e.g. where we have a single cross-section of test score in mathematics examinations. These variable is entered into the panel estimation for growth. In this estimation, the test scores vary cross-sectionally but do not vary over time within countries. This estimation is quietly similar to those in Barro (2001), on the difference that we use a fixed-effects technique, where Barro uses a three-stage-least square technique. However, Barro has data for only 43 countries, that represents the third of number of countries that we include in our regression (approximately 120 countries). We suppose that contemporaneous tests scores in mathematics and science can be viewed as proxies of schooling quality. In table 2, we use tests scores with time variation, instead of simple proxies.

The first column of table 1 includes variables generaly employed in growth regressions (e.g. Barro, 1997). The initial level of GDP per capita at each of the ten-year periods is included to measure the conditional rate of convergence to the steady state growth rate. These variables are : The log of life expectancy, investment rate, a rule-of-law index, inflation rate, government consumption and international trade.

Most results are similar to those of Barro (1997). Higher initial GDP is significantly associated with lower growth rates. Higher trade and lower inflation also lead to higher growth. Moreover, growth rates are higher with better institutions.

The effect of higher government consumption is not obvious a priori. On the one hand, a large government sector may induce inefficiencies and crowd out the private sector. On the other, the provision of an efficient infrastructure and a proper legal framework may promote growth (Hansson, 2000). However, as presented in table 1, government consumption does not significantly influence economic growth. Investment has a positive impact on economic growth, but its coefficient is significant only at the 11% level of significance. To account for the quality of the legal system and the enforceability of property rights, a rule of law index constructed by Gwartney and Lawson (2002) is included in the regression. Results presented in table 1 show a positive and significant effect of this index on economic growth.

Results in column (1) show that when we control for fixed effects, quantity of schooling doesn't have an effect on economic growth. The inclusion of the qualitative indicator of schooling, instead of the years of education show a positive and highly significant effect : an increase of one standard deviation of quality of schooling (10 points) tends to increase economic growth of 1.9 percentage points. When we include both indicators relating to education, only the indicator of quality is significant. Moreover, the effect seems to be slightly higher, compared to the results in column (2). It is necessary here however to moderate the amplitude of these coefficients, for at least two reasons. First of all, if education creates positive externalities, then the coefficient associated with our indicators may be over-estimated. Because of omitted variables, the coefficient associated with the educational indicators may include other factors. In addition, as Bils and Knelow (2000) note, there may be a double relation of causality between education and growth: if education certainly has an impact on economic growth, such growth also probably has a return effect on education. In this case, the coefficient found could explain an opposite relation of causality between education and growth. We take this assumption into account below.

King and Levine (1993) argue that the quality of a country's financial markets can influence economic growth. Indeed, we include a proxy relating quality of financial markets – e.g. liquid liabilities. Confirming results found in Chanda (2001) and Dreher (2006). With the inclusion of this variable, quality of education still remains significant but its coefficient is highly reduced from 0.226 to 0.162.

In recent years, political and institutional variables have been found to have an impact on growth (for a review, see Carmignani, 2001). Sala-i-Martin (1997) reports a positive influence of civil liberties and political rights on growth. The inclusion of proxies of political and institutional variables – e.g. civil liberties, political rights and executive constraints – do not change the coefficient related to quality of schooling. Coefficient related to political rights is troubling, because it means that the more the political rights are weak, the more the economic growth will be high. Executive constraints – which is a measure of the extent of institutionalized constraints on the decision making powers of chief executives – has a negative and significant effect on economic growth. Again, as it is shown in column (5), (6) and (7), schooling quantity does not seem to play a key role in explaining economic growth.

In table 2, we present results when the panel dimension of schooling quality is introduced. It should be noted that number of observations dramatically decrease when we include this proxy. Two different proxies of quality of schooling are used: the international score in mathematics in secondary schools (columns (1), (3) and (4)) and the international score in science in secondary schools (columns (2), (5) and (6)). In columns (1) and (2), we use fixed effects OLS technique. Neither score in mathematics nor score in science seem to play a key role in economic growth. However, there may be a potential endogeneity bias with some of the variables. Hence, we carry out using the GMM dynamic panel estimators suggested by Blundell and Bond (1998). While Arellano and Bond (1991) use a first differenced estimator to avoid the correlation of the lagged dependent variable with the individual effect included in the error term, Arellano and Bover (1995) reinclude levels equations in combination with suitable lags of first differences encounter the weak instruments problem discussed by Staiger and Stock (1997). Moreover, they show that adding the levels equations considerably increases the precision of the estimator, especially when the autocorrelation of the dependent variable is relatively high.

However, the overall number of instruments becomes disproportionally high in some regressions, sometimes higher than the number of countries included in the panel. Due to the additional levels restrictions, this problem arises more often with the Blundell-Bond estimator, which is used in our regressions. Roodman's (2006) implementation of this estimator in Stata suggests an easy way to mitigate this problem through a limitation of the lags to be considered as instruments. In our analysis, this option is always used in order to improve overall regression statistics, in particular the test for validity of the overidentifying restrictions (Hansen test). For Blundell-Bond estimation, one-step and two-step options are available. Arrelano and Bond's (1991) simulations suggest that the two-step option may increase the precision of coefficient estimates and considerably improve overall regression statistics in case of heteroscedasticity, but that standard errors tend to be systematically underestimated. This systematic bias is taken into account by the robust version of the estimators implemented by Roodman (2006) which include Windmeijer's (2005) finite-sample correction for the two-step covariance matrix.

We now regress the natural logarithm of per capita GDP at the end of a ten-year period on its lag and other variables, as opposed to regressing the growth rate on these variables. However, the formulation of the model in differences means that the regression shows how changes in quality of schooling affect growth. Columns (3) to (6) present results from the Blundell-Bond two-step GMM estimator. On the basis of the Blundell-Bond estimator, a Hansen test on the validity of the instruments can be conducted. This amounts to a test for the exogenety of the covariates. As can be seen in columns (3) to (6), the Hansen test always accepts the over-identifying restrictions. Hence, strict exogeneity is not rejected. The Arellano-Bond test of second order autocorrelation, which must not be present in the data in order for the estimator to be consistent, also accepts all specifications.

With one exception, the results are similar to those obtained with OLS: GDP per capita at the beginning of the period is now significantly positive. This confirms the results of Dollar and Kray (2001). When score in mathematics is considered as a proxy of quality of schooling, its coefficient is positive and significant. When science score is used, only the estimation without control variables is significant. Compared to the previous results, the magnitude of the coefficient is quite similar. The estimate show that a ten point increase in the quality of schooling increases GDP growth by 12 percentage points (column (4)). The average yearly growth thus equals about 1.2 percentage points, sligthly higher than the previous results of 0.9. Quantity of schooling is still insignificant when we include panel dimension of quality of schooling.

As very few countries participated several times to international surveys on educational achievement, number of observations in table 2 is very low. Hence, it should be useful to test directly the impact of quantity of schooling in a larger sample. In table 3, we test this assumption. In columns (1) to (3), we include only quantity of schooling, wheras in columns (4) to (6), we adjust quantity of schooling by its quality measure. In this way, we test whether the readjustment of the average number of school years by the quality of education can improve our measurement of education, by supposing that one school year in a considered country is not identical to the same year in another country. The value obtained by calculating this indicator can thus be regarded as an average number of school years adjusted by the quality of education. Hence, we calculate $S_{QIHC,it}$ which is equal to

$$S_{QIHC,it} = S_{it} \times QIHC_i \big/ QIHC_{USA} \quad (5)$$

In order to have comparable data, we choose years of schooling in the USA as reference years. This combinaison supposes that quality of schooling does not vary over time for country *i* but only between countries. Although this hypothesis can be called into question, the lack of data for quality of schooling over time make it quite impossible to permit variations over time. Hence, we suppose that only years of education vary over time.
Table 3 presents results with and without adjusting for quality of schooling. In columns (1) to (4), we don't adjust for quality of schooling. When we regress the variation of quantity of schooling on economic growth, the effects appears positive and significant : an increase of one year of schooling increases GDP growth by 4 percentage points. The average yearly growth rate thus equals about 0.4 percentage points. When variable related to liquid liabilies is included in the specification, quantity of schooling is no longer significant. The combinaison between quantity and quality of schooling shows more robust results: coefficients associated to this variable is always positive and significant. The magnitude of the coefficient is similar compared to non-adjusted years of schooling.
In order to check for the robustness of the analysis, we subdivide sample into two groups: OECD and developing countries. Results presented in table 4 show that when we distinguish countries by their economic level, only the combinaison between quantity and quality of schooling appears robust. Non-adjusted years of schooling have an effect only in the OECD countries. On the contrary, adjusted years of schooling have a positive and significant effect on economic growth in both OECD and non-OECD countries. Moreover, the effect of schooling is more important in developing countries than in developed countries. An increase of one adjusted-year of schooling increases annual GDP growth by 0.23 percentage points in OECD countries, while the increase is about 0.72 percentage points in non-OECD countries.

Hence, the effect of schooling seems to be more important in developing countries. It can be viewed as a convergence effect of schooling on economic growth.

5. Concluding remarks

Among all the explanations for economic growth, one generally accepted explanation concerns the level of human capital. The seeming obviousness of the idea, however, has meet with inconsistencies in the existing literature. The most robust macro-economic analyses reveal contradictions in the relationship between education and growth. Pritchett (2001) showed that very often the impact of education on growth is negative and significant. However, the majority of these studies ignored the qualitative dimension of human capital, recognising only the purely quantitative indicators.

Using national or international surveys into the pupil assets in mathematics and sciences makes it possible to fill this gap in qualitative measurement. Hanushek and Kimko (2000) and Barro (2001) used qualitative variables, but did not exploit all of the international investigations or all the countries surveyed (36 countries in the first study and 43 countries in the second). In this research study, we used a method which enabled us to obtain qualitative indicators of human capital (*QIHC*) for approximately 120 countries, and for each academic subject (mathematics, sciences, reading). Consequently, our sample includes more developing countries than the two principal existing studies in this field.

The estimate of the relationship between education and growth reveals the positive role played by the quality of education: when the *qualitative* dimension of education is taken into account, we find positive and significant effect from education to economic growth. Whatever the specifications selected (with or without variables of control), the effect of quality of education is always positive and significant on the growth rate of the economy.

An important problem had to be addressed: as economic growth also plays a part in explaining the quality of education systems, it was necessary to make use of a simultaneous equations model. Taking account of the possible endogeneity of education - via the two educational indicators - made it possible to distinguish the possible double causal relationship between education and growth. With this endogenization, the effect of education on growth is maintained. Education thus has a real effect on the growth rate of an economy.

Nevertheless, the estimated effect of the quality of education on growth may be over-estimated: indeed, our results show that an increase by one standard deviation in the quality of education brings with it an increase by 0.9 point in the average annual growth. As Hanushek and Kimko (2000) indicated, there is no direct and clear relationship between differences in productivity in the profits of individuals of different nations and the economic growth of those nations. It is highly possible that the quality of education generates positive externalities and thus encourages a nation into a higher cycle of growth. This argument underlines the possibility of omitted variables in the growth specifications, but we have little information on their nature. By including a certain number of them (private investment, rate of trade, democracy), the qualitative and quantitative effects of education remained positive.

It is thus necessary to proceed cautiously in measuring the magnitude of the effect of education on growth. However, by confirming preceding analyses which used qualitative indicators, we can conclude from our study that the quality of education is an important factor in growth. It now remains to determine the factors likely to improve the quality of education and thus to encourage economic growth of countries.

Appendix 1: Methodology of construction of the qualitative indicators of human capital

This appendix describes the methodology used to calculate the qualitative indicators of human capital. The qualitative indicators of human capital (QICH) can be regarded as an alternative to the strictly quantitative variables of education, such as schooling rates. The studies by Hanushek and Kimko (2000) and Lee and Barro (2001) already undertook this kind of readjustment. It is strictly speaking a question of quantifying on a scale from 0 to 100 the quality of education, more precisely the success rates of representative samples by various countries on international investigations into pupil assets. We take into account 7 various international tests. These surveys are SACMEQ (Southern and Eastern Africa Consortium for Monitoring Educational Quality), MLA (Monitoring Learning Achievement), PASEC (Programme on Analysis of Education Systems), LLCE (Latin American Laboratory for Assessment of the Quality of Education), PISA (Programme for International Student Assessment), TIMSS (Third International Mathematics and Science Study), PIRLS (Progress in International Reading Literacy Study). See appendix 3 for more information. The data were taken from Barro and Lee (2000) for the investigations prior to 1995 and from official reports for the other investigations. Below, we present a general methodology. For complete details on the investigations used and for further information relating to our methodology, see Altinok and Murseli (2007).

In the cross-section database, as there are eight international surveys analysing children's learning achievement, our study has tried to gather those surveys on a common scale in order to allow an international comparison of children's learning achievement across countries. First, we selected countries which participated in at least two different surveys so as to establish a comparison between the surveys. The IEA surveys were chosen as reference surveys as they cover most of the countries and as the economic levels of participating countries are the most heterogeneous. We will present the general methodology as applied to mathematics. Note that we only used tests dated after 1995, because we wanted to obtain qualitative indicators for the most recent year. All the surveys were then adjusted to a 0-100 scale, with 100 as the highest possible score. Starting from the TIMSS indexes, we tried to track countries which had participated in the TIMSS and at least one other survey. We then proceeded to a matching based on the means of those countries which participated in at least two surveys (called "doubloons"); each survey was re-adjusted according to how closely it fitted with the IEA survey which was taken as a reference. Finally, we proceeded to the calculation of the values of the initial survey, now re-adjusted according to the reference survey. As a result of these procedures, we were able to obtain all the re-adjusted results in mathematics referenced to the TIMSS survey. Moreover, for each country which provided adjusted results in several surveys, the mean of those results was calculated. In order to update this database, we use the indicators of Hanushek and Kimko (2000) (H&K) and those of Schoellman (2006). Hanushek and Kimko (2000) built a worldwide database of the results on international test scores for a sample of 39 countries (see for methodology, Hanushek and Kim, 1995). They took into account the results on international tests by the IEA (International Association for the Evaluation of Educational Achievement) and from the IAEP (International Assessment of Educational Progress). Tests were administrated to pupils belonging to different cohorts in 1965, 1970, 1981 and 1985 (IEA), 1988 and 1991 (IAEP) in 11, 17, 17, 17, 17, 6 and 19 countries, respectively. 39 countries contributed at least once, while the United States and Great Britain took part in the entire six series of tests. Schoellmann (2006) began by documenting three facts about how a country's education quality interacts with other labor market observables: it is positively correlated with the country's school quantity, uncorrelated with the country's return to schooling, and positively correlated with the returns

to schooling of that country's immigrants to the US. He develops a model which fits these facts, and which also suggests using the labor market returns of immigrants to the US as a measure of quality. For doing this, he uses the 5% sample of the 2000 Census Public Use Micro Survey, made available through the IPUMS (Integrated Public Use Microdata Series) system. In this database, immigrants are identified by country of birth. The Census lists separately each of 130 statistical entities with at least 10,000 immigrants counted in the United States. The final sample includes 4.1 million Americans and 220,000 immigrants from 130 different sources countries. In final, Schoellmann obtain quality measures for 80 countries.
As these databases have information on certain countries which we do not have, it is possible to consider that we can partially fill in missing values. For doing this, we carry out an OLS regression and determine the scores for each field of competences.

Concerning the panel database, we carry out a compilation of the whole of the investigations relating to the measurement of pupil assets at the primary and secondary levels. Two groups of tests can be distinguished: those in which the United States took part and which allow an anchoring with a specific test (test series A) and those in which the United States did not take part (test series B). For the first series of A investigations, we use an anchoring on an American investigation NAEP (National Assessment of Educational Progress) similar to that used by Hanushek and Kimko (2000). The NAEP is the principal measuring instrument of the assets of American pupils starting from 1969. The IAEP (International Assessement of Educational Progress) is the international equivalent of the NAEP. Thus, the evaluation procedure is based on the American results. At different periods since 1970, in the United States, pupils of 9, 13 and 17 years old were tested on their assets in sciences and mathematics. These tests can provide a measurement of absolute reference for the proficiency level of the United States. In order to process at the same time the data from the IEA and IAEP investigations, Hanushek and Kimko (2000) used the results of the United States as "doubloons ". They thus modified the averages of the IEA investigations in order to equalize them with those of the NAEP which were closest (in terms of age, year and field of competence). Unlike Hanushek and Kimko, we did not correct the scores a second time for measurement errors in order to obtain comparable indicators with those obtained from the B test series. For the B test series - those in which the United States did not take part - we carried out an anchoring of the investigations based on the results of countries which took part in at least two different investigations. In the end, we obtain 56 series of investigations for all the age groups (9, 10, 13, 14, 15 and the last year of secondary school). In order to obtain data comparable in terms of time and of corresponding educational variables, we did not take into account the test series for pupils in their last year of secondary school and or the pretests, which reduces the number of investigations to 42 series. In a final stage, since certain series roughly relate to the same year and the same school level (primary or secondary), regrouping them led finally to 26 test series spread out between 1964 and 2005 and for three fields of proficiency (mathematics, sciences and reading).

Appendix 2. Descriptive Statistics and Data Sources

Variables	Source	Obser-vations	Mean	Standard Deviation	Minimum	Maximum
Quantity of schooling: average years of schooling of people aged between 15 and 25.	Barro and Lee (2001) and Unesco (2004)	525	5.00	2.78	0.09	12.25
Quality of schooling in cross-section database						
QIHC Mathematics	Altinok and Murseli (2007)	104	69.80	16.58	22.69	100
QIHC Sciences		79	80.71	13.03	42.21	100
QIHC Reading		89	72.24	20.39	23.71	100
Quality of schooling in panel database :						
QIHC in panel for mathematics in secondary schools	Altinok and Murseli (2007)	165	48.32	9.70	21.9	78.31
QIHC in panel for science in secondary schools		177	52.19	7.87	17.94	73.67
Combination between Quantity and Quality of schooling in mathematics	Our calculuations	431	2.84	1.84	0.03	7.23
Log(Life Expectancy)	World Bank (2007)	697	4.11	0.20	3.47	4.39
Rule-of-law index	Gwartney and Lawson (2002)	429	5.82	1.17	3.05	8.73
Inflation Rate	World Bank (2007)	535	55.44	269.60	-1.33	3296.6
Government Consumption (in percent of GDP)	World Bank (2007)	583	16.38	7.00	4.45	58.31
Trade (in percent of GDP)	Penn World Tables 6,2 ; Heston, Summers and Aten (2002	592	73.77	41.84	2.09	287.21
Liquid liabilities	Beck *et al.* (1999)	472	0.42	0.33	0	3.06
Civil Liberties	Freedom House	636	3.95	1.83	1	7
Political Rights	Freedom House	636	3.99	2.10	1	7
Executive Constraints	Jaggers and Marshall (2006)	582	3.99	2.23	1	7

Appendix 3. Tests of competences used in the paper

Year	Organization	Field of Competence	Number of Countries	Age of pupils
1964	IEA	Mathematics	13	13, Fin sec.
1970-72	IEA	Sciences Reading	19 15	10,14, Fin sec. 10,14, Fin sec.
1982-83	IEA	Mathematics	20	13, Fin sec.
1984	IEA	Sciences	24	10,14, Fin sec.
1988	IAEP	Mathematics Sciences	6 6	13 13
1990-91	IAEP	Mathematics Sciences	20 20	9,13 9,13
1993-98	IEA	Mathematics Sciences	41 41	9,13, Fin sec. 9,13, Fin sec.
1992-1997	Unesco-MLA	Mathematics Sciences	13 11	10 10
1997	Unesco-LLCE	Mathematics Reading	11 11	10 10
1999	IEA	Mathematics Sciences	38 38	14 14
1995-2005	CONFEMEN-PASEC	Mathematics	11	9,10
2000	OECD-PISA	Mathematics Sciences	43 43	15 15
2002	Unesco-SACMEQ	Mathematics	14	10
2003	IEA	Mathematics Sciences	26,48 26,48	10,14 10,14
2003	OECD-PISA	Mathematics Sciences	41 41	15 15

Notes : "Fin. sec." : Final year of secondary, USA (Etats-Unis), IAEP (International Assessment of Educational Progress), IEA (International Association of the Evaluation of Educational Achievement), OECD (Organization for Economic Co-operation and Development), PISA (Programme for International Student Assessment), UNESCO (United Nations Educational, Scientific and Cultural Organization), CONFEMEN (Conference of Francophone Education Ministers), PASEC (Programme on Analysis of Education Systems), SACMEQ (Southern and Eastern Africa Consortium for Monitoring Educational Quality), MLA (Monitoring Learning Achievement).

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Table 1: Fixed Effects Results

	1965-2005 (10-year data in averages)						
	Fixed Effects OLS (1)	Fixed Effects OLS (2)	Fixed Effects OLS (3)	Fixed Effects OLS (4)	Fixed Effects OLS (5)	Fixed Effects OLS (6)	Fixed Effects OLS (7)
Log(per capita GDP), beginning of period	-4.423* (0.886)	-4.084* (0.849)	-4.528* (0.911)	-5.384* (1.061)	-4.359* (0.873)	-4.402* (0.866)	-4.508* (0.876)
Investment rate	0.107 (0.067)	0.087 (0.061)	0.110 (0.066)	0.122‡ (0.067)	0.111‡ (0.066)	0.106 (0.065)	0.105 (0.066)
Quantity of schooling	0.199 (0.344)		0.258 (0.350)	0.355 (0.370)	0.322 (0.356)	0.294 (0.348)	0.352 (0.355)
Quality of schooling		0.194* (0.035)	0.226* (0.070)	0.162* (0.050)	0.207* (0.073)	0.207* (0.072)	0.245† (0.113)
Log(Life Expectancy)	-1.048 (1.836)	-3.694 (2.334)	-1.766 (1.973)	-0.949 (1.875)	-2.147 (2.054)	-1.632 (1.937)	-1.078 (2.058)
Rule-of-Law Index	1.122* (0.258)	1.223* (0.278)	1.077* (0.265)	1.231* (0.284)	1.133* (0.248)	1.163* (0.242)	1.113* (0.253)
Inflation Rate	-0.066‡ (0.034)	-0.047 (0.051)	-0.054 (0.058)	0.076 (0.072)	-0.053 (0.058)	-0.052 (0.058)	-0.053 (0.059)
Government Consumption	0.056 (0.101)	0.016 (0.101)	0.057 (0.102)	0.055 (0.098)	0.059 (0.098)	0.058 (0.099)	0.064 (0.099)
Trade (% of GDP)	0.023‡ (0.012)	0.022‡ (0.011)	0.024† (0.012)	0.024‡ (0.012)	0.028† (0.012)	0.028† (0.012)	0.030† (0.012)
Liquid liabilities				1.226 (1.718)			
Civil Liberties					0.330 (0.226)		
Political Rights						0.313‡ (0.177)	
Executive constraints							-0.228† (0.106)
Constant	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	345	339	321	306	318	318	310
Countries	121	108	107	105	106	106	104
R-squared (adj.)	0.60	0.56	0.58	0.57	0.59	0.59	0.59

Notes : The dependent variable is the average GDP per capita growth rate (10 year data in averages, between 1965 and 2005). A dummy for each time period is included, the regression also include a dummy for each country. Robust standard errors clustered by country are in parentheses below coefficients.
Significance levels: *1%. †5%. ‡10%.

Table 2: Fixed effects results with panel dimension of QIHC

	1965-2005 (10-year data in averages)					
	Fixed Effects OLS (1)	Fixed Effects OLS (2)	System GMM (3)	System GMM (4)	System GMM (5)	System GMM (6)
Log(per capita GDP), beginning of period	-6.133* (1.461)	-4.544* (1.048)	0.862* (0.109)	0.736* (0.106)	0.827* (0.060)	0.665* (0.108)
Investment rate	0.149‡ (0.077)	0.114 (0.083)	0.014 (0.004)	0.012 (0.004)	0.011† (0.004)	0.006 (0.008)
Quantity of schooling	0.618 (0.501)	-0.037 (0.545)	0.000 (0.038)	-0.012 (0.036)	0.014 (0.022)	0.028 (0.027)
Quality of schooling 1 (maths score)	0.020 (0.059)		0.008‡ (0.005)	0.012‡ (0.007)		
Quality of schooling 2 (science score)		0.023 (0.047)			0.010† (0.005)	0.006 (0.004)
Log(Life Expectancy)	0.589 (5.683)	-5.792 (3.766)		-0.149 (0.770)		0.035 (0.213)
Rule-of-Law Index	1.176‡ (0.626)	1.715 (0.409)		0.095* (0.034)		0.132* (0.039)
Inflation Rate	0.167 (0.101)	0.133‡ (0.078)		0.018* (0.007)		0.017‡ (0.009)
Government Consumption	-0.138 (0.104)	-0.029 (0.124)		0.013‡ (0.007)		0.008 (0.007)
Trade (% of GDP)	0.023 (0.017)	0.033† (0.015)		-0.000 (0.000)		0.000 (0.001)
Constant	Yes	Yes	No	No	No	No
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Country Dummies	Yes	Yes	No	No	No	No
AR(1) Test			[0.02]	[0.02]	[0.05]	[0.04]
AR(2) Test			[0.17]	[0.16]	[0.15]	[0.84]
Hansen Test			[0.49]	[0.47]	[0.28]	[0.38]
Countries	62	62	71	62	70	62
Observations	130	141	143	130	156	141
R-squared (adj.)	0.96	0.82				

Notes : In the OLS regressions, the dependent variable is the average GDP per capita growth rate (10 year data in averages, between 1965 and 2005). When estimated with GMM, the natural logarithm of per capita GDP at the end of each 10-year period is employed. A dummy for each time period is included, the OLS regressions also include a dummy for each country. Robust standard errors are in parentheses below coefficients. Standard errors are clustered by country in Fixed effects OLS regressions.
Significance levels: *1%. †5%. ‡10%.

Table 3: Fixed effects results with combination of schooling indicators

	Panel database, 1965-2005 (10-year data in averages)							
	Quantity of schooling				*Schooling years adjusted by quality of schooling*			
	System GMM (1)	System GMM (2)	System GMM (3)	System GMM (4)	System GMM (5)	System GMM (6)	System GMM (7)	System GMM (8)
Log(per capita GDP), beginning of period	0.636* (0.062)	0.715* (0.086)	0.650* (0.063)	0.607* (0.060)	0.685* (0.062)	0.734* (0.095)	0.688* (0.059)	0.645* (0.059)
Investment rate	0.013* (0.004)	0.012* (0.005)	0.011* (0.004)	0.011* (0.004)	0.013* (0.005)	0.012† (0.005)	0.013* (0.005)	0.013* (0.004)
Quantity of schooling	0.042† (0.019)	0.034 (0.021)	0.050† (0.020)	0.055* (0.019)				
Schooling years adjusted by quality of schooling					0.040† (0.016)	0.040‡ (0.021)	0.043† (0.018)	0.046* (0.017)
Log(Life Expectancy)	0.793* (0.236)	0.699* (0.249)	0.742* (0.248)	0.847* (0.240)	0.561† (0.239)	0.624† (0.269)	0.534† (0.229)	0.667* (0.234)
Rule-of-Law Index	0.111* (0.025)	0.134* (0.029)	0.112* (0.023)	0.114* (0.024)	0.093* (0.024)	0.124* (0.030)	0.092* (0.022)	0.092* (0.021)
Inflation Rate	-0.011* (0.003)	-0.010‡ (0.006)	-0.011* (0.003)	-0.010* (0.003)	-0.002 (0.008)	-0.001 (0.009)	-0.003 (0.007)	-0.002 (0.008)
Government Consumption	0.010 (0.008)	0.006 (0.008)	0.009 (0.008)	0.012 (0.008)	0.006 (0.006)	0.001 (0.008)	0.005 (0.007)	0.009 (0.007)
Trade (% of GDP)	-0.001 (0.001)	0.000 (0.001)	-0.001 (0.001)	-0.001 (0.001)	-0.000 (0.001)	0.001 (0.001)	0.000 (0.001)	-0.000 (0.001)
Liquid liabilities		-0.196 (0.143)				-0.243 (0.163)		
Civil Liberties			0.019 (0.021)				0.013 (0.020)	
Executive constraints				-0.020‡ (0.011)				-0.013 (0.010)
Constant	No	No	No	No	No	No	No	No
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Dummies	No	No	No	No	No	No	No	No
AR(1) Test	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
AR(2) Test	[0.59]	[0.97]	[0.51]	[0.70]	[0.83]	[0.98]	[0.75]	[0.91]
Hansen Test	[0.19]	[0.24]	[0.25]	[0.38]	[0.08]	[0.14]	[0.09]	[0.12]
Observations	344	326	341	333	320	305	317	309
Countries	121	117	120	118	107	105	106	104

Note : The dependent variable is the natural logarithm of per capita GDP at the end of each 10-year period. A dummy for each time period is included. Robust standard errors are in parentheses below coefficients.
Significance levels: *1%. †5%. ‡10%.

Table 4: Fixed effects results with combination of schooling indicators, Subsamples

	Panel database, 1965-2005 (10-year data in averages)					
	Quantity of schooling			*Schooling years adjusted by quality of schooling*		
	OECD Countries	Developing Countries	Without Asian Countries	OECD Countries	Developing Countries	Without Asian Countries
	System GMM (1)	System GMM (2)	System GMM (3)	System GMM (4)	System GMM (5)	System GMM (6)
Log(per capita GDP), beginning of period	0.829* (0.055)	0.622* (0.073)	0.680* (0.063)	0.826* (0.054)	0.647* (0.068)	0.712* (0.068)
Investment rate	0.019* (0.003)	0.008 (0.006)	0.006 (0.006)	0.017* (0.003)	0.008 (0.007)	0.003 (0.006)
Quantity of schooling	0.030* (0.009)	0.043 (0.027)	0.035 (0.021)			
Schooling years adjusted by quality of schooling				0.023* (0.007)	0.072* (0.025)	0.044† (0.019)
Log(Life Expectancy)	-1.648† (0.664)	0.882* (0.232)	0.820* (0.196)	-1.326† (0.624)	0.594† (0.225)	0.671* (0.228)
Rule-of-Law Index	0.069* (0.021)	0.119* (0.033)	0.105* (0.030)	0.070* (0.020)	0.111* (0.033)	0.098* (0.031)
Inflation Rate	-0.054 (0.067)	-0.009† (0.004)	-0.009† (0.004)	-0.043 (0.065)	-0.004 (0.006)	-0.003 (0.006)
Government Consumption	0.007 (0.005)	0.012‡ (0.006)	0.012‡ (0.006)	0.006 (0.005)	0.013† (0.006)	0.009 (0.007)
Trade (% of GDP)	0.001† (0.000)	-0.000 (0.001)	0.001 (0.001)	0.001† (0.000)	-0.000 (0.001)	0.002† (0.001)
Constant	No	No	No	No	No	No
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Country Dummies	No	No	No	No	No	No
AR(1) Test	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
AR(2) Test	[0.09]	[0.75]	[0.30]	[0.09]	[0.97]	[0.32]
Hansen Test	[0.97]	[0.39]	[0.19]	[0.99]	[0.07]	[0.01]
Observations	106	238	303	106	214	284
Countries	30	91	108	30	77	97

Note : The dependent variable is the natural logarithm of per capita GDP at the end of each 10-year period. A dummy for each time period is included. Robust standard errors are in parentheses below coefficients.
Significance levels: *1%. †5%. ‡10%.