NBER WORKING PAPER SERIES

SCHOOLING, COGNITIVE SKILLS, AND THE LATIN AMERICAN GROWTH PUZZLE

Eric A. Hanushek
Ludger Woessmann

Working Paper 15066
http://www.nber.org/papers/w15066

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
June 2009

We benefited from helpful comments from Paul Romer and participants of the Stanford Conference on Latin America and the Caribbean and gratefully acknowledge support by the Inter-American Development Bank (IADB) and CESifo. The views expressed herein are those of the author(s) and do not necessarily reflect the views of the National Bureau of Economic Research.

Schooling, Cognitive Skills, and the Latin American Growth Puzzle
Eric A. Hanushek and Ludger Woessmann
NBER Working Paper No. 15066
June 2009
JEL No. H4,I2,O4,N16

ABSTRACT

Economic development in Latin America has trailed most other world regions over the past four decades despite its relatively high initial development and school attainment levels. This puzzle can be resolved by considering the actual learning as expressed in tests of cognitive skills, on which Latin American countries consistently perform at the bottom. In growth models estimated across world regions, these low levels of cognitive skills can account for the poor growth performance of Latin America. Given the limitations of worldwide tests in discriminating performance at low levels, we also introduce measures from two regional tests designed to measure performance for all Latin American countries with internationally comparable income data. Our growth analysis using these data confirms the significant effects of cognitive skills on intra-regional variations. Splicing the new regional tests into the worldwide tests, we also confirm this effect in extended worldwide regressions, although it appears somewhat smaller in the regional Latin American data than in the worldwide data.

Eric A. Hanushek
Hoover Institution
Stanford University
Stanford, CA 94305-6010
and NBER
hanushek@stanford.edu

Ludger Woessmann
University of Munich
Ifo Institute for Economic Research
Poschingerstr. 5
81679 Munich, Germany
woessmann@ifo.de

1. Introduction

If transported back to 1960, one might well have expected Latin America to be on the verge of significant economic growth. Both its level of school attainment and its income level were well ahead of East Asia and of the Middle East and North Africa (MENA) region (Table 1). But by 2000, growth in East Asia had moved that region far ahead of Latin America. While not going as far, the MENA region also jumped ahead, leaving only Latin America and Sub-Saharan Africa at the bottom with very low growth rates and commensurate low income per capita.[1] This outcome remains a puzzle by conventional thinking. Why did Latin America have such a poor growth performance relative to Asia and even MENA, given its high schooling level in 1960? While much attention has been given to institutional and financial factors,[2] we suggest that the level of cognitive skills is a crucial component of the long-run picture.

In simplest terms, while Latin America has had reasonable school attainment, what students in fact know is comparatively very poor. Student achievement on international tests in both Latin America and Sub-Saharan Africa are near the bottom of the international rankings, while student performance in MENA and especially East Asia are much higher. As Figure 1 reveals, consideration of the low level of cognitive skills appears sufficient to reconcile the poor growth performance of Latin America with outcomes in the rest of the world over the past four decades. Our interpretation is simple: Even though many things enter into economic growth and development, the cognitive skills of the population are extremely important for long-run growth. In the presence of measures of cognitive skills, school attainment does not even have a significant relationship with growth. A crucial missing link in explaining why Latin America went from reasonably rich in the early post-war period to relatively poor today is its low cognitive skills. This link also helps explain the variations in economic performance across Latin America. These findings are in line with the growing literature revealing the central role of cognitive skills in economic development in general (see Hanushek and Woessmann (2008, 2009) for review and discussion of the evidence).

[1] Even there a mystery remains, because Latin America has considerably higher levels of school attainment in 2000 than does Sub-Saharan Africa. Of course, the recent spurt in growth in Latin America might represent a turnaround, but that would require a very uncertain extrapolation.

[2] See, for example, Fernández-Arias, Manuelli, and Blyde (2005) and Edwards, Esquivel, and Márquez (2007).

Focusing on the relationship between cognitive skills and economic development in Latin America does introduce two analytical concerns. First, the prior work had relatively few observations from Latin America (seven of the available 50 countries in the analysis in Hanushek and Woessmann (2008)), making it difficult to analyze patterns of within-region economic outcomes. Second, the international assessments of math and science skills may simply be too difficult for the typical Latin American student, making the comparisons across Latin American countries unreliable.

The performance of Latin American countries on the worldwide student achievement tests has been truly dismal. A motivating concern of this paper is that Latin American students may be so far from OECD countries that the details of the scores may not be meaningful. Because test efficiency requires the international assessments to focus testing time on discriminating performance in the vicinity of the international mean, there may not be sufficient test questions that reliably distinguish performance well at the level of most Latin American countries.

To address these difficulties, we explore the use of regional measures of cognitive skills that were designed specifically for Latin American countries when revisiting variations in long-run growth (measured over the period 1960-2000). While Latin American countries participated only sporadically in the worldwide student achievement tests, the Laboratorio Latinoamericano de Evaluación de la Calidad de la Educación (LLECE) conducted two regional tests of student performance in math and reading that together cover all sixteen Latin American countries usable in analyses of national growth.[3] The first LLECE assessment tested third and fourth grade students in 1997, the second survey – the Segundo Estudio Regional Comparativo Explicativo (SERCE) – tested third and sixth grade students in 2006. Neither of these is perfect, because they measure performance just in early grades and because both are very recent – with the second test actually occurring outside of the period for which growth is observed. Nonetheless, their regional test designs and broad coverage of countries hold promise for regional analyses. To our knowledge, neither of the tests has been used before in models of economic outcomes.

Our results using the regional test data support the important role that cognitive skills play in understanding Latin American growth. These test scores are statistically and quantitatively

[3] The criteria are having populations greater than one million and no communist background. We do not include Caribbean island countries in the analyses of this paper, as only two of them ever participated in the tests. Cuba lacks internationally comparable income data, and the remaining country – the Dominican Republic – proves a strong outlier in analyses of the Latin American mainland countries (see below).

significant in predicting economic growth in intra-regional growth regressions. They increase the explanatory power of standard growth models considerably and render the effect of years of schooling insignificant. In sum, schooling appears relevant for economic growth only insofar as it actually raises the knowledge that students gain as depicted in tests of cognitive skills.[4]

It also proves feasible to splice the regional educational assessments into the worldwide assessments. In the extended sample of 59 countries that now includes 16 Latin American countries, cognitive skills are again significantly associated with economic growth in worldwide growth regressions. The estimated effects of cognitive skills are smaller in the Latin American sample than in the rest of the world, however, which may be due to higher measurement error in the more recent and primary-school measures of Latin American skills, to a lower importance of cognitive skills in the institutional framework of Latin American countries, or to a curvilinear relationship between cognitive skills and growth. Currently available data do not allow us to distinguish between these interpretations.

This paper begins with a conceptual framework for the relationship between years of schooling, cognitive skills, and economic growth. Following this, we elaborate on the description of cognitive skills in Latin American countries and use the worldwide test data to provide initial analyses of Latin American growth in worldwide comparison. Next, we develop alternative performance measures based on the regional tests and turn to variations in economic outcomes within Latin America. Finally, we combine the regional with the worldwide measures of cognitive skills to place the larger set of Latin American countries into the overall world distribution of economic growth.

2. Schooling, Cognitive Skills, and Growth: A Conceptual Framework

Theoretical models of economic growth have emphasized different mechanisms through which education may affect economic growth. Augmented neoclassical growth theories building

[4] While this paper focuses on the macroeconomic aspects of education in a cross-national comparison, existing microeconomic studies are in line with the crucial role of education for economic success in Latin America. In the studies estimating individual returns to education surveyed in Psacharopoulos and Patrinos (2004), Latin American countries (together with Sub-Saharan Africa) have the highest labor-market returns to years of schooling among all world regions. Over the past decades, these returns also tended to increase in Latin America (cf. Pritchett (2004); Behrman, Birdsall, and Székely (2007)). Apart from the returns to education quantity, labor-market returns to cognitive skills in the one Latin American country that participated in the International Adult Literacy Survey, Chile, are the second-highest of all participating countries (after the United States; Hanushek and Zhang (2008)).

on Mankiw, Romer, and Weil (1992) stress the role of education as a production factor that can be accumulated, increasing the human capital of the labor force and thus labor productivity. Theories of endogenous growth in the spirit of Romer (1990) and Aghion and Howitt (1998) stress the role of education in increasing the innovative capacity of the economy. Theories of technological diffusion such as Nelson and Phelps (1966) and Benhabib and Spiegel (2005) stress that education may facilitate the transmission of knowledge needed to implement new technologies. All approaches have in common that they predict that education a positive effect on growth, and in particular the latter two stress its impact on long-run growth trajectories.

An increasing wave of empirical growth research, following the seminal contributions by Barro (1991, 1997) and Mankiw, Romer, and Weil (1992), tries to estimate why some countries grow faster than others. The recent literature, involving cross-country growth regressions and invariably considering the impact of education, relies mostly on the important internationally comparable data on average years of schooling provided by Barro and Lee (1993, 2001) and its refinements as the proxy for the human capital of an economy (Cohen and Soto (2007)). These analyses tend to find a significant positive association between quantitative measures of schooling and economic growth.[5] Moreover, various branches of the accumulated work have attempted to distinguish among alternative mechanisms behind this association and have delved into measurement and specification issues – while generally supporting a role for schooling in determining growth (see the review in Hanushek and Woessmann (2008)).

An alternative perspective, originating in the work of Hanushek and Kimko (2000), concentrates directly on cognitive skills. As documented in Hanushek and Woessmann (2008), a series of studies pursuing different variations of skill measurement and specification supports a substantial and robust effect of cognitive skills on economic growth that dwarfs the association between years of schooling and growth.

Our current analysis, focusing on Latin American growth, builds on this literature, which relies on the following model:

$$g = \gamma H + \beta X + \varepsilon \tag{1}$$

where g is the growth rate of real GDP per capita over an extended period, H is human capital, X are other factors affecting growth, and ε is a stochastic term where it is assumed that

[5] For extensive reviews of the literature, see Topel (1999), Krueger and Lindahl (2001), and Pritchett (2006).

$E(H, X|\varepsilon) = 0$. X includes the initial level of income, the economic institutions of the country, and a variety of other control variables.

The typical growth analysis simply substitutes a measure of school attainment for *H* and proceeds to estimate Equation (1). But doing so requires two very strong assumptions that each lack prima facie validity. First, it must be the case that a year of schooling produces the same knowledge and skills, or human capital, regardless of the country. For example, a year of schooling in Peru must be equivalent to a year in Japan, a difficult position to argue from the aggregate data below. Second, and equally important, schooling must be the only systematic factor influencing skills, something that is refuted in virtually all individual-level analyses of achievement (Hanushek (2002)).

We expand on these measurement aspects by considering alternative sources of human capital accumulation:

$$H = \delta_1(qS) + \delta_2 F + \delta_3 A + \nu \tag{2}$$

This formulation builds on the extensive literature of educational production functions. The components determining *H* include years of schooling (*S*) and schooling quality (*q*), family factors (*F*), and other attributes (*A*) including health, ability, and labor-market experience of the country's population. Equation (2) suggests how inputs into the formation of human capital, such as schooling levels, could be used as a proxy for human capital when direct measures are unavailable. But, it also indicates how the interpretation would be affected if only an imperfect set of measures is available.[6]

Instead of estimating the components of Equation (2), however, we turn to direct measures of cognitive skills, stemming from international testing initiatives to measure educational achievement across countries, as indicators of *H*. Although human capital is a latent variable that is not directly observed, the use of measures of cognitive skills has a number of potential advantages. First, it captures variations in the knowledge and ability that schools strive to produce and thus relate the putative outputs of schooling to subsequent economic success.

[6] Hanushek and Woessmann (2008) elaborate on this model to consider imperfect measurement of *H,* particularly the consideration of noncognitive skills. Because schooling is likely to be correlated with the other determinants of human capital and we do not separately identify their effects, we see our results as measuring the effect of cognitive skills combined with that part of other human-capital components, including noncognitive skills, which is correlated with cognitive skills.

Second, by emphasizing total outcomes of education, it incorporates skills from any source – families, schools, and ability. Third, by allowing for differences in performance among students with differing quality of schooling (but possibly the same quantity of schooling), this formulation opens the investigation of the importance of different policies designed to affect the quality aspects of schools.

In terms of econometric identification, the extent to which associations found in cross-country growth regressions can be interpreted as causal effects has been the subject of controversy for a long time. Beginning with the analysis of Levine and Renelt (1992), evidence of the sensitivity of results to model specification has been plentiful. In terms of years of schooling, Bils and Klenow (2000) provide convincing evidence of the endogeneity of school attainment in growth models. Hanushek and Woessmann (2009) address the issue of causality between cognitive skills and growth with several econometric techniques.[7] Using different instrumental-variable and differences-in-differences approaches to identify the causal impact of cognitive skills, they provide general support for a causal interpretation of the relationship between cognitive skills and growth.[8] Further, they demonstrate that schooling can be a policy instrument contributing to economic outcomes to the extent that it contributes to cognitive skills. Here, we do not repeat the analysis in Hanushek and Woessmann (2009). Instead, we concentrate on whether the general framework provides insights into the long-run economic performance of Latin American countries.

3. Cognitive Skills in Latin America: A Description

The existing data from worldwide student achievement tests paint a bleak picture of performance in Latin America.[9] While Latin American countries have not participated

[7] Aghion, Boustan, Hoxby, and Vandenbussche (2005) use within-country variation in the United States to address causality issues in the relationship between investments in college education and growth.

[8] An extensive sensitivity analysis shows the results are insensitive to the sample of countries, to the specific tests employed, or to estimation within separate regions. The analysis of causality first considers the earnings of immigrants to the U.S. and finds that the international test scores for their home country significantly explain U.S. earnings for those educated in their home country but not for those educated in the U.S. Further, changes in test scores over time are systematically correlated with changes in growth rates over time. Finally, instrumenting by institutional features of school systems does not change the growth results. See Hanushek and Woessmann (2009) for details.

[9] Throughout the paper, our analysis focuses on Latin American countries with greater than one million population. (The Latin American countries of Belize, French Guiana, Guyana, and Suriname all have population less than one million). We exclude Nicaragua from the economic analysis because of its extended period under communist rule

frequently in the existing testing, the performance is uniformly not competitive with either developed or many developing countries.

Between 1964 and 2006, international agencies performed a total of 46 different international student achievement tests in math, science, or reading on 16 separate international testing occasions (several of which tested more than one subject and age level).[10] Only seven Latin American countries ever participated in any of the international math or science tests: Argentina, Brazil, Chile, Colombia, Mexico, Peru, and Uruguay.[11]

Before 2000, just Chile and Colombia participated in math or science tests based on an international curriculum, and their performance was at the bottom (between the second- and fourth-last rank on five different occasions that included between 12 and 39 participating countries), only outperforming a handful of countries such as India, Iran, Malawi, and South Africa.[12] In IEA assessments after 2000, other Latin American countries also established positions near the bottom. Argentina and Colombia, for example, were fifth and sixth from the bottom (with only Belize, Morocco, Kuwait, and Iran below) in the 2001 Progress in International Reading Literacy Study (PIRLS) of 4th graders.

International testing expanded considerably in 2000 when the Organisation for Economic Co-operation and Development (OECD) started the Programme for International Student Assessment (PISA), which tests 15-year-old students in mathematics, science, and reading every three years. Yet, by 2006, only seven Latin American countries participated in any of the PISA

---

and nonmarket conditions. Caribbean countries, while sometimes put together with Latin American countries, are not included in this analysis. No Caribbean country ever participated in the worldwide testing of math and science. Apart from Cuba, which lacks internationally comparable income data, only one Caribbean country (the Dominican Republic) ever participated in the regional testing and, as described below, is a strong outlier if combined into the analysis of Latin American countries.

[10] The available tests emanate from two main organizations – the International Association for the Evaluation of Educational Achievement, or IEA, and the OECD. The IEA introduced international testing in 1964 and has conducted periodic assessments up to the current TIMSS (Trends in Mathematics and Science Study). The OECD began international testing in 2000 with the Programme for International Student Assessment, or PISA. Both continue on a periodic schedule, and both the IEA and OECD have added reading assessments.

[11] As discussed below, all Latin American countries (with more than one million population) have participated in one or both regional testing programs conducted in 1997 and 2006 – a fact that we exploit below. On the international tests, Venezuela did participate in a 1991 reading test, and their student scores only exceeded those in Botswana, Nigeria, and Zimbabwe on the test for 13-year-olds and no other country on the test for 9-year-olds.

[12] All worldwide testing considered in this paper is based on international collaboration designed to capture the typical curricular elements found across countries. An exception is the International Assessment of Educational Progress (IAEP) study which mirrors the U.S. curriculum. Brazil participated in the IAEP study in 1991, coming out second from the bottom (followed only by Mozambique) among 19 countries in math and last among 18 countries in science.

rounds, and the results mirrored the earlier testing. In 2000 and 2003, Indonesia and Tunisia were the only countries to keep Brazil and Mexico off the bottom of the 31 participants in the three tested subjects. In 2002, an additional ten countries took the 2000 test. Peru came out last, at an amazing distance, among the combined sample of 41 countries, whereas Argentina and Chile performed between sixth and eighth from the bottom on the three subjects (followed only by Albania, Indonesia, and Macedonia outside Latin America). Six Latin American countries participated in the PISA 2006 cycle: Four of them are among the bottom ten in math and science out of a total of 57 participating countries. The only Latin American country ever making it to the "top 40" of the 57 countries is Chile (with rank 39 in reading).

As a simple summary, for the 59 occasions on which a Latin American country participated in an international student achievement test (counting different subjects and age groups separately), the average rank was 36.9 among an average of 41.5 participants (where a significant portion of the ranks below were taken up by other Latin American countries).

For our growth analysis, however, we need a description not just of the rank but of the magnitude of score differences. Comparing the level of performance across tests is difficult, because no attempt is made to calibrate the tests across time and a varying group of countries has voluntarily participated in each of the existing international assessments. In order to make performance on the international mathematics and science tests comparable and usable to analyzing growth, Hanushek and Woessmann (2009) develop a common metric for the tests between 1964 and 2003. The development of a common metric involves adjusting both the level of test performance and its variation across the different assessments. First, each of the separate international tests is benchmarked to a comparable level by calibrating the U.S. international performance over time to the external standard of the available U.S. longitudinal test (the National Assessment of Educational Progress, NAEP). Second, the dispersion of the tests is standardized by holding the score variance constant within a group of 13 OECD countries with relatively stable secondary school attendance rates over time. This empirical calibration puts all the international tests on the metric of the PISA test, which has a mean performance across the OECD countries of 500 and a standard deviation (at the student level) of 100.

Figure 2 depicts the average performance between 1964 and 2003 on the standardized tests for the 50 countries contained in our growth analyses below, that is, all countries that have both participated in one of the tests and have comparable income data. There is a clear performance

gap between the best country in Latin America and the worst OECD country, or any country in East Asia with the exception of Indonesia and the Philippines. In fact, the later two countries, together with the African participants, are the only countries that consistently perform worse than any of the Latin American countries. Even the best-performing Latin American country, Uruguay, on average performs a full 0.70 standard deviations below the OECD mean. Peru, the worst-performing country in Latin America, is nearly two standard deviations below the OECD mean (see also column (5) of Appendix Table A1 for the Latin American data).

Nonetheless, such a comparison of the performance of those in school will even understate the true gap in average cognitive skills between full cohorts. Enrollment in secondary school has not been universal in Latin American countries, leading to more selective test taking in these countries compared to most others in Figure 2.

If we assume that those children who dropped out of school before ninth grade did not reach functional literacy, and if we take a test-score performance of one standard deviation below the OECD mean (400 points on the PISA score) as depicting a basic level of functional literacy in mathematics and science, we can get a rough measure of the share of a cohort who really reach basic literacy. Less than 5 percent of tested students fall below this threshold of basic literacy in developed countries such as Japan, the Netherlands, Korea, Taiwan, and Finland. But, *of those who stayed in school until age 15,* as many as 82 percent in Peru and 66 percent in Brazil do not reach such a level of basic literacy in cognitive skills.

For three Latin American countries, we can combine performance on international tests with data from Demographic and Health Surveys (cf. Filmer (2006)) that provide reliable measures of the share of children aged 15-19 who reached different levels of school attainment. Figure 3 breaks down each cohort into those who have completed grade 9 and reach a level of basic skills on the international test, those who have completed grade 9 without reaching basic literacy, those who dropped out between grades 5 and 9, those who dropped out between grades 1 and 5, and those who never enrolled.[13] In Brazil and Peru, the share of recent cohorts that can be termed functionally literate is as small as 8 percent and 12 percent, respectively – a number smaller only in Ghana and South Africa among the countries with available data (cf. Hanushek and

[13] The figure combines educational attainment of 15-to-19-year-olds from the latest available year with test scores at the end of lower secondary education from a year close by. Specifically, Peru combines attainment data for 2000 with test scores of 15-year-olds in PISA 2002, Brazil combines 1996 attainment data with PISA 2000, and Colombia combines 2000 attainment data with test scores of eighth-graders on TIMSS 1995.

Woessmann (2008)). The remaining roughly 90 percent of the population in Brazil and Peru have to be viewed as illiterate – either because they never enrolled in school, because they dropped out of school at the primary or early secondary level, or because completing lower secondary education did not equip them with even a basic level of cognitive skills. In Colombia, the share of functionally literates in a cohort in their late teens is greater but still only 30 percent.

The bottom line of the performance of Latin American countries on the worldwide tests is truly dismal: The average cognitive skills of Latin American students are consistently near or at the bottom of the international distribution, and only a very small fraction of each young cohort reaches a level of even the most basic cognitive skills by international standards.

Indeed, Latin American students may be so far from OECD countries that the observed within-region differences of their scores on the worldwide achievement tests is not very meaningful. International assessments, like those in other circumstances, are designed with an underlying notion of test efficiency. Specifically, in order to reliably assess differences among students, there must be sufficient test questions to provide information that distinguishes among varying levels of performance. This implies that there are relatively fewer questions farther from the central tendency of the students for whom the test is designed. The relatively fewer questions limit the amount of development effort and test time devoted to populations far from the target population. The international tests that are designed primarily for developed countries (who support the testing in general) are thin in questions that would allow discriminating among performance in the tails of the distribution. As a result, there may be insufficient test questions on the worldwide tests to distinguish reliably among varying levels of learning in the region of Latin American students. We will return to this crucial theme below.

4. Analyzing Latin American Growth with Worldwide Skill Measures

We began by using the data of the worldwide tests of cognitive skills to evaluate the extent that the poor cognitive skills in Latin America can account for the region's poor growth record. Table 2 starts with the regression underlying Figure 1. The simple model of the combined test-score measure (derived from the scores in Figure 2) and initial GDP per capita can account for 99 percent of the variation in average annual growth in GDP per capita in 1960-2000 across the six world regions (column 1). In the aggregate, the poor average level of cognitive skills fully accounts for the poor post-war growth performance of Latin America. As the subsequent

columns reveal, the initial GDP alone does not have any predictive power, nor do years of schooling when added to the model. Because many Latin American countries are well-known to have followed import substitution policies over significant parts of the period, we also added standard measures of trade policies to the model (not shown). Test scores retain their significant effect when openness is added to the model, while openness does not enter significantly.[14]

The aggregation of Figure 1 and the first columns of Table 2 masks the considerable variation within Latin American countries (see Appendix Table A1). For example, more than a whole standard deviation distinguishes the average cognitive skills in Peru (312) from Uruguay (430). Average years of schooling in 1960 were a mere 2 years in Guatemala, Honduras, and El Salvador, as opposed to more than 6 years in Chile and Argentina. Likewise, economic performance shows substantial variation among the Latin American countries. The level of GDP per capita in 1960 ranges from below $2,000 in Honduras and Ecuador to more than $7,000 in Venezuela and Argentina – close to the mean of European countries. The growth experience between 1960 and 2000 ranges from negative in Venezuela to almost three percent per year in Brazil. As a consequence of the differing initial income levels and growth experiences, GDP per capita in 2000 ranges from about $2,000 in Honduras to more than $10,000 in Argentina.

Column (5) of Table 2 replicates the basic specification of a worldwide country-level growth regression of Hanushek and Woessmann (2008) and shows that the highly aggregated picture is corroborated in analyses performed at the country level. Cognitive skills are strongly associated with long-run growth across the 50 countries that have ever participated in a worldwide student achievement test (and have internationally comparable data on GDP growth).[15] In this basic specification, test scores that are larger by one standard deviation (measured at the student level

[14] Although test scores and openness are strongly correlated across world regions, the explained share of cross-regional growth variation is considerably lower when entering openness instead of test scores in the model (where openness enters significantly as long as test scores are not entered).

[15] Hanushek and Woessmann (2008, 2009) show that the association between cognitive skills and economic growth proves extremely robust to including obvious additional control variables such as economic institutions, geography, and fertility, to different sets of sub-samples of countries, to restricting the test-score measure to specific periods, subjects, or age groups, and to applying the analysis to immigrants from different countries on the same U.S. labor market. As in the continental analysis, considering trade policies does not compromise the importance of skills: Both openness and cognitive skills enter significantly positive in a joint country-level specification. Furthermore, the explanatory power of cognitive skills in terms of accounting for growth variation is considerably larger. In addition, Hanushek and Woessmann (2008) show that the effect of cognitive skills interacts positively with the openness of the economy: While skills have positive effects even in closed economies, they are significantly bigger in open economies. Hanushek and Woessmann (2009) also show that several instrumental variables and differences-in-differences specifications warrant a causal interpretation of the association.

across all OECD countries in PISA) are associated with an average annual growth rate in GDP per capita that is two (1.98) percentage points higher over the whole 40-year period.

In the final column, we allow the test-score effect to differ between the seven Latin American countries and the rest of the world. With these data, it is not possible to obtain reliable estimates of any differences for the Latin American countries compared to others in the world. The Latin American dummy and its interaction with test scores are individually and jointly (F-statistic 1.38, p-value 0.262) statistically insignificant, although the interaction comes close. (This result holds if interactions of the Latin American dummy with years of schooling and initial GDP are included, which are strongly insignificant). The relatively imprecise estimate for the Latin American subset may not only reflect the small sample of seven countries, but also the relatively low informational content of worldwide testing for Latin American countries.

5. Intra-Regional Analyses of Cognitive Skills and Growth in Latin America

We now explore the use of two intra-regional achievement tests specifically designed to capture cognitive skills in Latin American countries. A key element of this is investigation of the underlying causes of differences in growth among the countries of the region.

5.1 Regional Achievement Tests in Latin America

The poor performance of Latin American countries on the worldwide tests poses a severe problem for the accuracy of intra-regional analyses of cognitive skills. While the PISA and TIMSS tests can accurately place student performance near the OECD mean, they are less reliable at distinguishing among the students in the tails of the distribution. As a consequence, the differences recorded among Latin American countries undoubtedly contain considerable noise, even though several thousand students in each country take the tests.

Starting in the 1990s and aided by UNESCO, Latin American countries developed tests of math and reading skills that could be applied across the region. In 1997, the Latin American Laboratory for the Assessment of Quality in Education – Laboratorio Latinoamericano de Evaluación de la Calidad de la Educación (LLECE) – carried out the "First International Comparative Study in Language, Mathematics, and Associated Factors in the Third and Fourth Grades of Primary Education" (Primer Estudio Internacional Comparativo) specifically designed to test cognitive skills in Latin American countries (see Laboratorio Latinoamericano de

Evaluación de la Calidad de la Educación (1998, 2001, 2002) for details). For ease of reference, we will refer to this study as "LLECE" throughout this report. LLECE provides data on educational performance for nine Latin American countries that also have internationally comparable GDP data.

LLECE tested the performance in math and reading of representative samples of students in each participating country in primary schools. The study released country medians in each grade and subject; in our analyses, we use performance of the older students (fourth grade).[16] The LLECE scores are standardized to have an international mean of 250 test-score points and a standard deviation of 50 among participating countries. Median math performance ranges from 226 in Venezuela to 269 in Argentina and Brazil, and median reading performance from 233 in Bolivia to 286 in Chile. In other words, student performance across countries differs by around one standard deviation on the tests – a huge within-region variation.

In 2006, the Latin American bureau of the UNECSO also conducted the "Second Regional Comparative and Explanatory Study" (Segundo Estudio Regional Comparativo Explicativo, or SERCE) designed for Latin American countries (cf. Laboratorio Latinoamericano de Evaluación de la Calidad de la Educación (2005, 2008a, 2008b)). It covers 13 countries usable in growth analyses. Combining the LLECE and SERCE studies, a total of 16 Latin American countries[17] – all Latin American countries with populations greater than one million and without communist background – can be used in our regional growth analyses.[18]

SERCE tested the performance in math and reading of representative samples of students in third and sixth grades, reporting country medians in each grade and subject.[19] In our analyses, we again use the performance of the older (sixth-grade) students (see Appendix Table A1). The SERCE scores are standardized to have an international mean of 500 test-score points and a standard deviation of 100 among participating countries. Across the 13 countries, median

[16] Median LLECE fourth-grade test scores are reported in Appendix Table A1. Scaling is based on a Rasch model that allows for differences in question difficulty. Results of growth analyses that use third-grade scores are similar.

[17] Bolivia, Honduras, and Venezuela participated in LLECE but not in SERCE, while Costa Rica, Ecuador, El Salvador, Guatemala, Panama, Peru, and Uruguay participated only in SERCE. Six countries (Argentina, Brazil, Chile, Colombia, Mexico, and Paraguay) participated in both tests.

[18] Both tests also included Cuba and the Dominican Republic, and SERCE also included Nicaragua. Nicaragua and Cuba are excluded because of their history of nonmarket economies, although Cuban students scored dramatically higher than students in the Latin American countries. The Dominican Republic was excluded as the sole remaining Caribbean country, which turns out to be a strong outlier if included in the growth analysis (see below).

[19] SERCE also tested a much more limited sample of countries in science in sixth grade.

performance (averaged across math and reading) ranges from about 454 in Ecuador and Guatemala to 560 in Uruguay, again revealing a within-regional difference of median performance of more than one standard deviation.

5.2 Regional Growth Regressions

Are there economic implications of these knowledge and skill differences? Our first analysis mimics the worldwide analysis of growth by considering whether variations in performance on the Latin American tests provide reliable indications of variations in growth rates among Latin American countries. To make the results directly comparable with the worldwide regressions, we have re-scaled the Latin American tests in all the growth regressions so that they have the same mean and standard deviation as observed for the group of participating Latin American countries on the worldwide tests. This simple standardization, which by necessity is noisy given the small number of Latin American countries on the worldwide tests, does not affect the qualitative results or their significance.

Table 3 provides basic growth models that investigate the pattern of growth just within Latin America. The first two columns provide a simple benchmark of growth within the full set of 16 Latin American countries and within the nine countries for which we have cognitive skill data from the first test, LLECE. A simple model that regresses average annual growth in GDP per capita between 1960-2000 on GDP per capita in 1960 and on years of school attainment can explain roughly half of the variation in growth rates, with one year of average attainment being associated with around 0.4 percentage point higher annual growth.

The results when including cognitive skills in the model are encouragingly similar to the global results based on just the worldwide test scores. If we add the simple mean of the LLECE test scores in math and reading across the nine countries with available data (column (3)), the explanation becomes much more precise – explaining 87 percent of the variation in growth rates. There is evidence for conditional convergence. Once test scores are held constant, school attainment again does not enter significantly in the model, and the point estimate is even negative. Excluding school attainment does not compromise the explanatory power of the model (column (4)). Most importantly, cognitive skills are significantly associated with economic growth. In these specifications, test scores that are larger by one standard deviation are associated with an average annual growth rate in GDP per capita that is 2.6-2.9 percentage points

higher over the whole 40-year period – quite similar to the estimate obtained on the global sample using the worldwide achievement tests, which found a two percentage points higher growth rate for each standard deviation.[20]

There are, of course, multiple concerns with this analysis. While the LLECE tests provide a reliable measure of performance differences among Latin American countries, they have three important drawbacks. First, they refer just to performance at early grades, necessitating an assumption that such early performance is a reasonable index of performance throughout the schooling system. Second, the tests occur very recently and close to the end of the period for which we observe economic growth, necessitating an assumption that cognitive performance differences have been relatively stable over the prior decades. Finally, we are limited to just nine countries, raising questions about whether the results hold for all of Latin America.

We can partially deal with these concerns by bringing in results from the second testing, SERCE. These tests give us observations for performance in grade six. They also expand the sample to the entire region with all 16 relevant countries participating in either the first or the second test. These advantages are traded against the disadvantage that the testing is even more recent and entirely outside of the period of observed economic growth.

To employ this additional assessment, we aggregate the two tests using the sample of countries taking both assessments. Specifically, we first standardize both tests to have mean zero and standard deviation one among the six countries participating in both tests and then splice the two together based on the means of the available tests. Finally, we again re-scaled the combined score to match the mean and standard deviation among the Latin American countries participating in the worldwide tests.

The final three columns of Table 3 provide the extended analysis of growth differences across all Latin American countries. The results provide a similar picture to that for the restricted sample used in the prior columns.[21] Again, differences in cognitive skills noticeably

[20] The Dominican Republic proves an extreme outlier when estimating our model by robust regression techniques that downweight or drop outliers based on statistical indicators. Specifically, we employ a robust regression method which eliminates gross outliers with a Cook's distance measure greater than one and then iteratively downweights observations with large absolute residuals (implemented as *rreg* in Stata). This estimation attributes a weight of zero to the Dominican Republic, whereas the next lowest weight is 0.70 for Mexico (for a maximum weight of 1).

[21] We excluded Nicaragua a priori because of the extended period of nonmarket, communist regime. If, however, we add Nicaragua to column (6) of Table 3 and estimate by robust regression method (*rreg*), Nicaragua gets 0.32 weight while the next lowest country has a weight of 0.80 – confirming the exclusion.

boost our ability to explain differences in growth across the region. The fit is not as precise as that for the more limited set of countries, but the R^2 again shows a significant jump over the model that relies on just school attainment. The estimated impact of skills on growth is, however, appreciably smaller in this enlarged sample – undoubtedly partially reflecting the increased measurement error with both the recentness of the testing and the necessity of projecting scores for those not participating in both assessments.

The final column of the table introduces a measure of economic institutions into the growth models – protection against expropriation (see Acemoglu, Johnson, and Robinson (2001)). Similar to the results of other regions of the world (Hanushek and Woessmann (2008)), institutions are also important, but the role of cognitive skills remains even after considering institutional differences. Standard measures of openness as another measure of economic institutions do not enter the Latin American model significantly and do not affect the qualitative result on test scores (not shown).[22]

Prior investigations suggest that differences in the shape of the performance distribution may provide additional information about growth differences (Hanushek and Woessmann (2009); see also Pritchett and Viarengo (2009) for a related argument for Latin America). Specifically, the balance of people at both the top and the bottom of the distribution appear to enter into the explanation of world differences in growth (along with having obvious policy implications about the organization of the schooling sector). We addressed this in the intra-regional analysis (not shown) using information about the scores of the top and bottom quartile of each country's distribution. The limited variation across our sample, however, precluded separate identification and estimation of the impact of relative balance of different parts of the distribution.[23]

The results using the LLECE and SERCE measures of cognitive skills confirm that Latin American countries that have higher cognitive skills have experienced faster economic growth over the long run. Figure 4 illustrates clearly the role of cognitive skills in explaining growth differences within the region. These models push the available data hard. The limited number of observations and the availability just of recent test data for young children are of particular concern. On the other hand, the very low scores on the TIMSS and PISA tests suggest that

[22] Interactions between cognitive skills and the institutional measures do not enter significantly here.

[23] When we perform the analyses separately for math and for reading, qualitative results are very similar (not shown), reflecting the high correlation among the subjects (correlation coefficient = 0.84). Similarly, results are hardly affected when adding test scores from the lower grades (grade three) into the analyses (not shown).

measures of basic literacy are most relevant and argue for concentrating on testing differences at the very bottom end – which is what the LLECE and SERCE effectively are doing.

6. Latin America in the World: Combining Regional and Worldwide Tests

We can now return to the question of how the Latin American evidence fits into the worldwide analysis. Figure 2 and the prior description made it clear that the performance of the seven Latin American countries that ever participated in a worldwide test is very far down on the worldwide tests such as TIMSS and PISA. As mentioned, it is even questionable whether the variation in performance on these tests across individuals and schools in each country, as well as across countries in the region, is informative at all. Across the five Latin American countries that participated both in LLECE and in some worldwide achievement tests, there is no significant correlation between the LLECE score and the score on the global tests. However, the range of the average international test scores across these five countries is 364 to 415 points. Considering that only the lowest 16 percent of students in OECD countries perform below 400, variations in average test scores in this range will be based on information from a very limited set of test questions. This also means that estimates of the effect of worldwide test scores for Latin American countries are likely to suffer from severe attenuation bias due to measurement error.

Our new information of cognitive skills using tests designed for the region suggests that it might be possible to improve upon the prior estimates by using more reliable information about intra-regional variations in performance and by expanding the sample of countries observed in the region. In order to splice the new tests into the world picture, we presume that the regional mean on the worldwide tests provides a reasonable scale, but that the within-region placement of individual countries is not reliable. We splice the regional Latin American tests into the worldwide test metric by again re-scaling the regional tests to have the same mean and cross-country standard deviation that the seven Latin American countries that also participated in the worldwide tests have on these tests.

To facilitate comparisons, the first column of Table 4 replicates the standard cross-country regression already shown in column (5) of Table 2 that uses only the worldwide tests. If we re-estimate the worldwide growth models simply substituting our new regionally-based measures of cognitive skills in the original seven Latin American countries in the analysis, the results are virtually identical in terms of the importance of cognitive skills, the explanation of growth

differences around the world, and the other model parameters (column (2) of Table 4). Given this, we then expand the world sample by adding all of the countries in Latin America.

The full regional estimates in column (3) show a noticeably smaller impact of cognitive skills on growth, with the coefficient falling roughly from 2 to 1½ percentage points annual growth associated with a standard deviation of test performance. Column (4) estimates separate impacts of cognitive skills in Latin America and in the rest of the world. This estimation shows the non-Latin America impact of a standard deviation of test performance to be two percentage points per year, while the Latin America impact is only 0.8 percentage points (significantly different from zero and from the estimated impact in the rest of the world).[24]

Figure 5 depicts the marginal impact of test scores on growth based on this last specification. The Latin American countries, which fall at the bottom of the growth rate chart, have a noticeably flatter pattern with cognitive skills than elsewhere.

Three different and not mutually exclusive possibilities offer potential explanations for this pattern. The Latin American pattern might simply reflect measurement error in the tests that attenuates the estimates in the usual manner. The recentness of the regional Latin American testing and its restriction to primary school are obvious causes of measurement error and attenuation bias in the regional test-score data. The different parameter estimates would be reconciled if the variance of the measurement error was roughly 60 percent of the total variance in the scores. Alternatively, the role of cognitive skills might simply be less within the Latin American economies. Such an interpretation would be in line with the evidence in Hanushek and Woessmann (2008) that the effect of cognitive skills interacts positively with growth-promoting economic institutions. A variant on the latter explanation that appears in Figure 5 is that the growth relationship might not be linear but might have a flat segment at low skills and perhaps a segment of increasing steepness at the top.[25] However, such an interpretation carries some arbitrariness, given that the usual scaling of tests is anchored only in the underlying assumption that skill distributions are roughly normal. Unfortunately, given currently available data, it is not possible to distinguish between these different perspectives.

---

[24] The results are unchanged if interactions of the Latin American dummy with years of schooling and initial GDP are also included, which do not enter significantly.

[25] The data for the rest of the world suggests that the importance of cognitive skills for East Asian countries has been larger than that for other countries (see Hanushek and Woessmann (2009)). Given the generally high performance of East Asian countries (Figure 2), this finding also supports a curvilinear relationship.

7. Conclusions

Economic growth in Latin America over the past half century has been disappointing and puzzling. The region historically has had relatively high levels of school attainment, leading by 2001 to expected school attainment of 13 years, compared to 8.6 in South and West Asia, 7.1 in Sub-Saharan Africa, and 9.5 across all developing countries (UNESCO (2005)). Yet these human capital investments have not translated into clear patterns of growth and development.

The growth puzzle is reconciled by consideration of the level of cognitive skills across Latin America. The average achievement of Latin American students on international tests is substantially lower than in East Asia and MENA and nearly as dismal as in Sub-Saharan Africa.[26] Despite their relative success in achieving high levels of school attainment, the knowledge that students in Latin America have gained by their mid-teens is staggeringly low. We show that in countries such as Brazil and Peru that provide the necessary data, only about one in ten children of each cohort can be termed functionally literate in their late teens.

Not only does the low level of cognitive skills account for the lack of growth of Latin America relative to the other world regions, but it also provides much of the explanation for variations in economic performance within Latin America. The strong effect of cognitive skills on economic growth is evident within the group of Latin American countries participating in the Latin American LLECE and SERCE tests of student achievement. This conclusion is based, however, on limited measures of relatively recent differences in mathematics and reading at the primary-school level, and it will be important to confirm this with expanded assessments.[27]

By ignoring differences in what students actually know, the existing literature very significantly misses the true importance of education for economic growth in Latin America.

---

[26] Sub-Saharan Africa is actually very similar to Latin America from an analytical standpoint. The international tests, which have been taken by a relatively small number of African countries, also appear too difficult for the typical student. On the other hand, regional testing initiatives such as the Southern and Eastern Africa Consortium for Monitoring Educational Quality (SACMEQ) and the Program on the Analysis of Education Systems (PASEC) in Francophone Sub-Saharan Africa possibly provide a platform both for better linkages to economic comparisons with the rest of the world and for intra-regional analysis.

[27] An implication of the limited informational content of worldwide tests such as TIMSS and PISA for developing countries is that it is important to develop ways to expand the tests at the lower levels so that both the between- and within-country variation is more reliable. It may be advisable to develop tests geared towards the performance levels relevant for these countries that allow a clear diagnosis of performance at levels equivalent to, say, 200 to 400 points on the PISA test, while at the same time including link items that allow anchoring these tests to the global assessments. The evolving capacity for adaptive testing that can adjust test content to students' ability levels seems particularly promising in this context.

Our results reveal that school attainment is associated with economic growth only insofar as it produces cognitive skills – something that happens to a far too limited extent in Latin America.

From a policy perspective, our results suggest that a vital aspect for education policy focus in Latin America (and elsewhere) may be how to ensure that students really acquire knowledge while in school. Rather than sticking to goals for school attainment, the primary focus of the Education for All initiative and the Millennium Development Goals, education policy may be more effective when focusing on the quality of education.[28] While this is increasingly recognized (see, for example, Duryea, Navarro, and Verdisco (2008)), it has yet to drive policy.

From an analytical perspective, this analysis has demonstrated the feasibility of linking different assessments for the analysis of economic outcomes. Not only do the regional tests provide greater and more reliable detail on country differences at the low end of the economic distribution, but they also point to how comparisons can be made to the rest of the world.

[28] The Education for All initiative of UNESCO and the World Bank has set goals for education to be reached by 2015. While quality of education is one of the six major goals, it has generally been overshadowed by quantitative goals for school attainment; cf. UNESCO (2005). The Millennium Development Goals of the United Nations explicitly focus on universal primary education by 2015. See http://www.un.org/millenniumgoals/bkgd.shtml.

References

Acemoglu, Daron, Simon Johnson, and James A. Robinson. 2001. "The colonial origins of comparative development: An empirical investigation." *American Economic Review* 91,no.5 (December):1369-1401.

Aghion, Philippe, Leah Boustan, Caroline M. Hoxby, and Jérôme Vandenbussche. 2005. "Exploiting states' mistakes to identify the causal impact of higher education on growth." (mimeo), Department of Economics, Harvard University.

Aghion, Philippe, and Peter Howitt. 1998. *Endogenous Growth Theory*. Cambridge, MA: MIT Press.

Barro, Robert J. 1991. "Economic growth in a cross section of countries." *Quarterly Journal of Economics* 106,no.2 (May):407-443.

———. 1997. *Determinants of Economic Growth: A Cross-Country Empirical Study*. Cambridge, MA: MIT Press.

Barro, Robert J., and Jong-wha Lee. 1993. "International comparisons of educational attainment." *Journal of Monetary Economics* 32,no.3 (December):363-394.

———. 2001. "International data on educational attainment: Updates and implications." *Oxford Economic Papers* 53,no.3 (July):541-563.

Behrman, Jere R., Nancy Birdsall, and Miguel Székely. 2007. "Economic policy changes and wage differentials in Latin America." *Economic Development and Cultural Change* 56,no.1:57-97.

Benhabib, Jess, and Mark M. Spiegel. 2005. "Human capital and technology diffusion." In *Handbook of Economic Growth*, edited by Philippe Aghion and Steven N. Durlauf. Amsterdam: North Holland:935-966.

Bils, Mark, and Peter J. Klenow. 2000. "Does schooling cause growth?" *American Economic Review* 90,no.5 (December):1160-1183.

Cohen, Daniel, and Marcelo Soto. 2007. "Growth and human capital: good data, good results." *Journal of Economic Growth* 12,no.1 (March):51–76.

Duryea, Suzanne, Juan Carlos Navarro, and Aimee Verdisco. 2008. "Learning about education quality and perceptions." In *Beyond facts: Understanding quality of life; Development in the Americas 2009*, edited by Inter-American Development Bank. Washington, DC: Harvard University Press.

Edwards, Sebastian, Gerardo Esquivel, and Graciela Márquez, eds. 2007. *The Decline of Latin American Economies: Growth, Institutions, and Crises*. Chicago, IL: University of Chicago Press.

Fernández-Arias, Eduardo, Rodolfo Manuelli, and Juan S. Blyde, eds. 2005. *Sources of Growth in Latin America: What Is Missing?* Washington, DC: Inter-American Development Bank.

Filmer, Deon. 2006. *Educational Attainment and Enrollment around the World. Development Research Group*. The World Bank 2006 [cited 2006]. Available from econ.worldbank.org/projects/edattain.

Hanushek, Eric A. 2002. "Publicly provided education." In *Handbook of Public Economics*, edited by Alan J. Auerbach and Martin Feldstein. Amsterdam: Elsevier:2045-2141.

Hanushek, Eric A., and Dennis D. Kimko. 2000. "Schooling, labor force quality, and the growth of nations." *American Economic Review* 90,no.5 (December):1184-1208.

Hanushek, Eric A., and Ludger Woessmann. 2008. "The role of cognitive skills in economic development." *Journal of Economic Literature* 46,no.3 (September):607-668.

———. 2009. "Do better schools lead to more growth?" NBER Working Paper No. 14633, Cambridge, MA, National Bureau of Economic Research.

Hanushek, Eric A., and Lei Zhang. 2008. "Quality consistent estimates of international returns to skill." (mimeo), Hoover Institution, Stanford University (March).

Heston, Alan, Robert Summers, and Bettina Aten. 2002. "Penn World Table Version 6.1." Center for International Comparisons at the University of Pennsylvania (CICUP), Philadelphia, University of Pennsylvania.

Krueger, Alan B., and Mikael Lindahl. 2001. "Education for growth: Why and for whom?" *Journal of Economic Literature* 39,no.4 (December):1101-1136.

Laboratorio Latinoamericano de Evaluación de la Calidad de la Educación. 1998. *First International Comparative Study of Language, Mathematics, and Associated Factors in Third and Fourth Grades*. Santiago, Chile: Latin American Educational Quality Assessment Laboratory.

———. 2001. *Primer Estudio Internacional Comparativo sobre Lenguaje, Matemática y Factores Asociados, para Alumnos del Tercer y Cuarto Grado de la Educación Básica: Informe Técnico*. Santiago, Chile: UNECSO-Santiago, Oficina Regional de Educación para América Latina y el Caribe.

———. 2002. *First International Comparative Study of Language, Mathematics, and Associated Factors in the Third and Fourth Grade of Primary School: Second Report*. Santiago,

Chile: UNECSO-Santiago, Regional Office of Education for Latin America and the Caribbean.

———. 2005. *Segundo Estudio Regional Comparativo Explicativo 2004-2007: Análisis Curricular*. Santiago, Chile: Oficina Regional de Educación de la UNESCO para América Latina y el Caribe (OREALC/UNESCO).

———. 2008a. *Los Aprendizajes de los Estudiantes de América Latina y el Caribe: Primer Reporte de los Resultados del Segundo Estudio Regional Comparativo y Explicativo*. Santiago, Chile: Oficina Regional de Educación de la UNESCO para América Latina y el Caribe (OREALC/UNESCO).

———. 2008b. *Student Achievement in Latin America and the Caribbean: Results of the Second Regional Comparative and Explanatory Study (SERCE) - Executive Summary*. Santiago, Chile: Regional Bureau for Education in Latin America and the Caribbean OREALC/UNESCO.

Levine, Ross, and David Renelt. 1992. "A sensitivity analysis of cross-country growth regressions." *American Economic Review* 82,no.4 (September):942-963.

Mankiw, N. Gregory, David Romer, and David Weil. 1992. "A contribution to the empirics of economic growth." *Quarterly Journal of Economics* 107,no.2 (May):407-437.

Nelson, Richard R., and Edmund Phelps. 1966. "Investment in humans, technology diffusion and economic growth." *American Economic Review* 56,no.2 (May):69-75.

Pritchett, Lant. 2004. "Access to education." In *Global Crises, Global Solutions*, edited by Björn Lomborg. Cambridge: Cambridge University Press:175-234.

———. 2006. "Does learning to add up add up? The returns to schooling in aggregate data." In *Handbook of the Economics of Education*, edited by Eric A. Hanushek and Finis Welch. Amsterdam: North Holland:635-695.

Pritchett, Lant, and Martina Viarengo. 2009. "Producing superstars for the economic mundial: The Mexican predicament with quality of education." Program on Education Policy and Governance, Cambridge, MA, Working Paper PEPG 09-01, Harvard University.

Psacharopoulos, George, and Harry A. Patrinos. 2004. "Returns to investment in education: A further update." *Education Economics* 12,no.2 (August):111-134.

Romer, Paul. 1990. "Endogenous technological change." *Journal of Political Economy* 99,no.5,pt. II:S71-S102.

Topel, Robert. 1999. "Labor markets and economic growth." In *Handbook of Labor Economics*, edited by Orley Ashenfelter and David Card. Amsterdam: Elsevier:2943-2984.

UNESCO. 2005. *Education for all: The quality imperative*, *EFA Global Monitoring Report*. Paris: UNESCO.

Appendix A. Descriptive Statistics

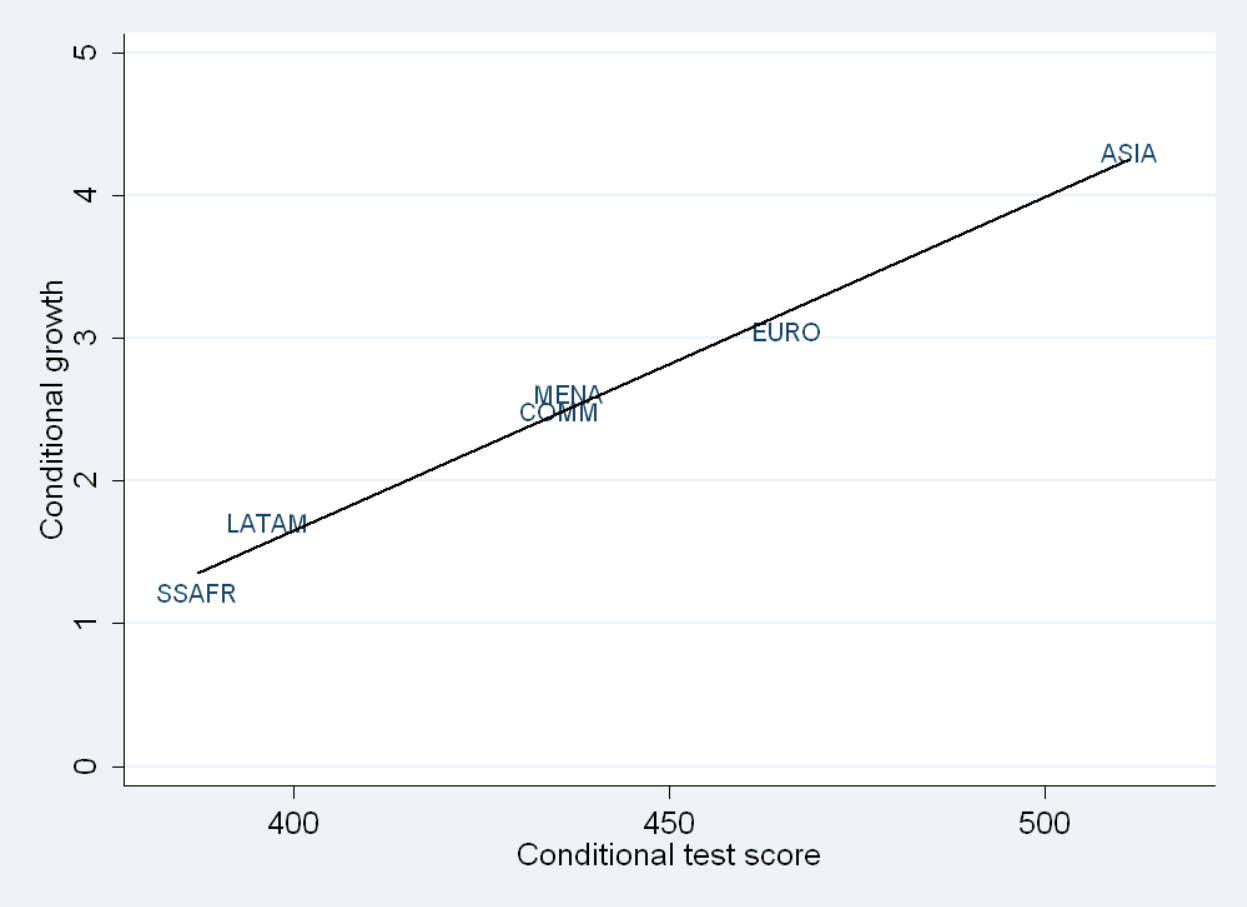
Table A1: Income and education of Latin American countries

	GDP per capita 1960	Growth of GDP per capita 1960-2000	GDP per capita 2000	Years of schooling 1960	Hanushek/ Woessmann internatl. score	LLECE (avg. math/reading, 4th grade)	SERCE (avg. math/reading, 6th grade)	LLECE + SERCE
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Argentina	7,395	1.0	10,995	6.1	392.0	275.5	509.7	395.3
Bolivia	2,324	0.4	2,722	3.6	–	239	–	264.0
Brazil	2,395	2.8	7,185	3.1	363.8	273	509.9	390.2
Chile	3,818	2.4	9,920	6.2	404.9	275.5	531.7	412.7
Colombia	2,525	1.9	5,380	3.7	415.2	261.5	503.8	361.4
Costa Rica	3,480	1.3	5,863	3.3	–	–	556.3	448.6
Ecuador	1,974	1.4	3,467	4.3	–	–	453.5	285.2
El Salvador	3,306	0.7	4,435	2.0	–	–	478.1	324.3
Guatemala	2,354	1.3	3,914	1.6	–	–	453.6	285.5
Honduras	1,705	0.5	2,054	1.9	–	234.5	–	245.3
Mexico	3,970	2.0	8,766	4.0	399.8	254	535.8	371.2
Panama	2,340	2.4	6,066	4.6	–	–	461.8	298.5
Paraguay	2,437	1.6	4,682	4.0	–	249.5	461.8	303.1
Peru	3,118	1.0	4,583	4.3	312.5	–	483.1	332.4
Uruguay	5,840	1.3	9,613	5.3	430.0	–	560.3	454.9
Venezuela	7,751	-0.5	6,420	2.9	–	237.5	–	257.8

Sample: All Latin American countries with populations greater than one million and without communist background; see footnote 9 for details.

Sources: Penn World Tables (Heston, Summers, and Aten (2002)); Cohen and Soto (2007); Hanushek and Woessmann (2009); Laboratorio Latinoamericano de Evaluación de la Calidad de la Educación (1998, 2008a).

Figure 1: Cognitive skills and economic growth across world regions



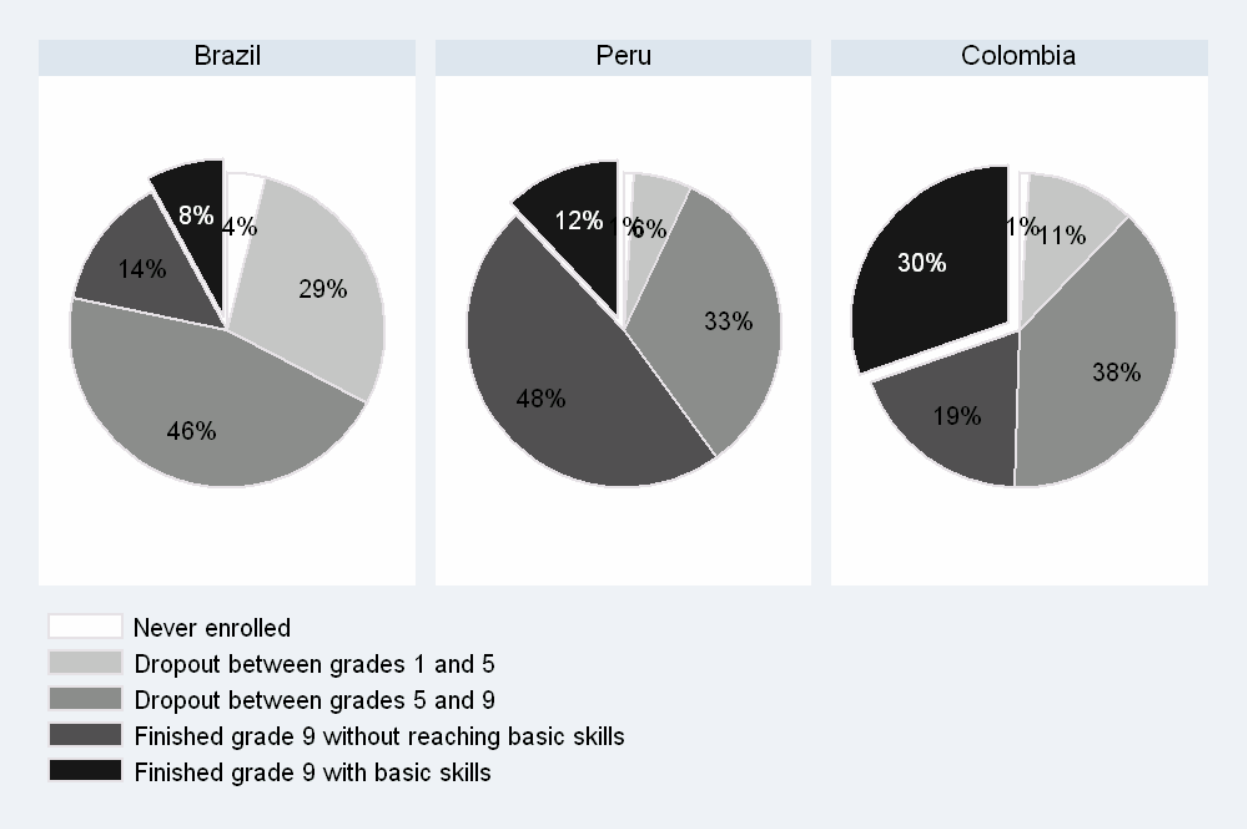
Added-variable plot of a regression of the average annual rate of growth (in percent) of real GDP per capita in 1960-2000 on the initial level of real GDP per capita in 1960 and average scores on international student achievement tests (mean of the unconditional variables added to each axis). Based on Table 2, column (1). See Table 1 for a list of countries contained in each world region.

Region codes: Asia (ASIA), Commonwealth OECD members (COMM), Europe (EURO), Latin America (LATAM), Middle East and North Africa (MENA), Sub-Saharan Africa (SSAFR).

Figure 2: Latin American performance on international student achievement tests

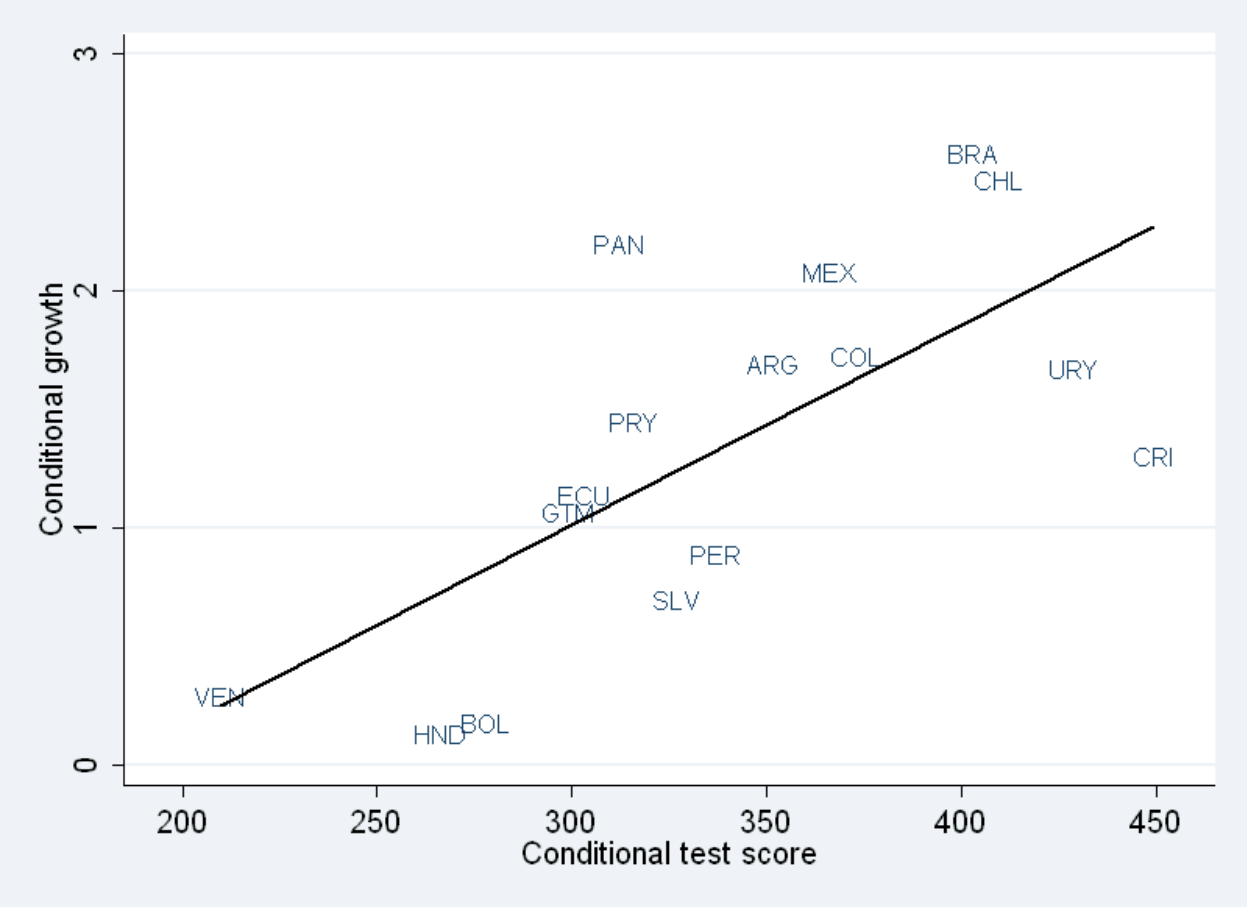
Simple average of mathematics and science scores over all international tests in 1964-2003, using the re-scaled data by Hanushek and Woessmann (2009) that puts performance at different international tests on a common scale.

Figure 3: Sources of lack of basic literacy in three Latin American countries



Own depiction based on Figure 14 of Hanushek and Woessmann (2008).

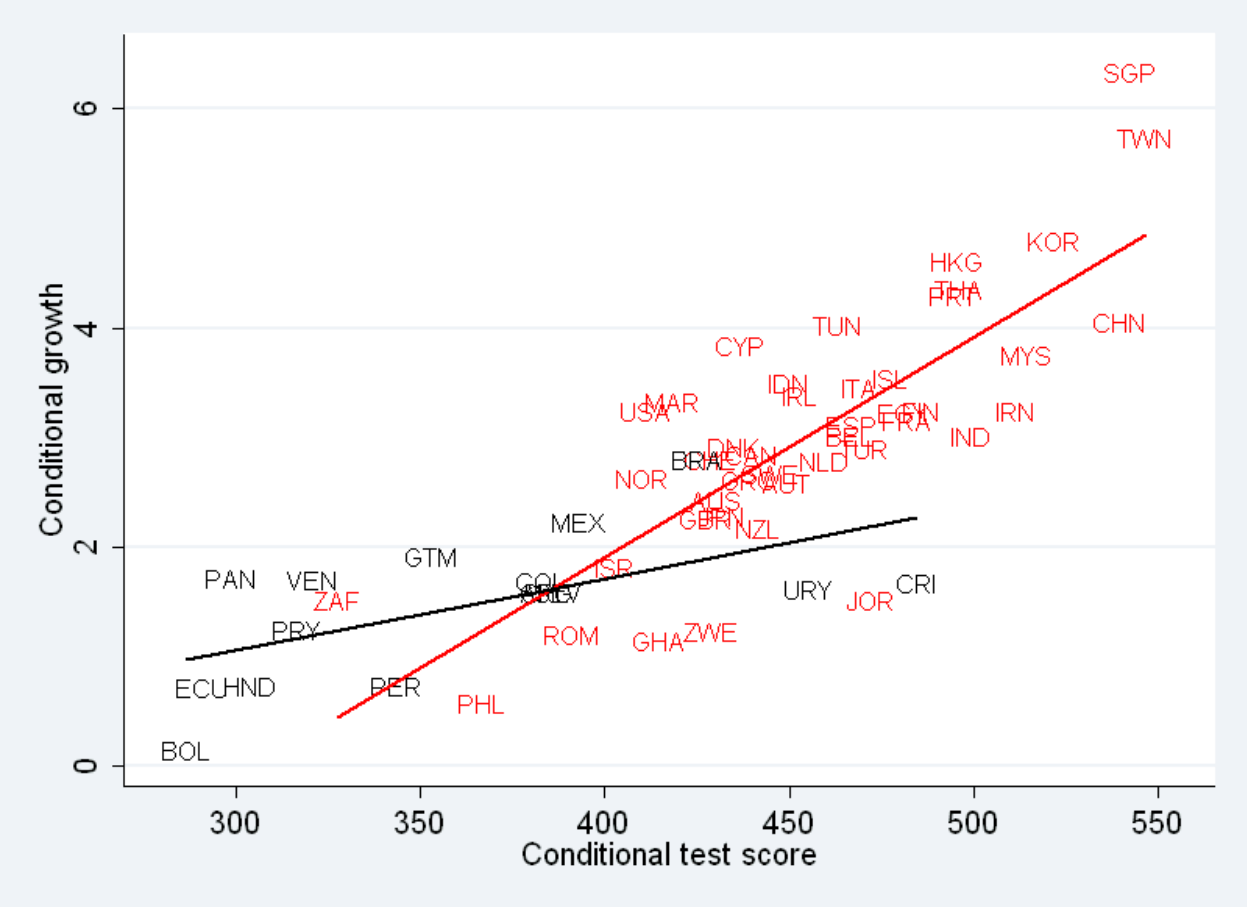
Figure 4: Cognitive skills and economic growth in Latin America



Added-variable plot of a regression of the average annual rate of growth (in percent) of real GDP per capita in 1960-2000 on the initial level of real GDP per capita in 1960 and average scores on Latin American student achievement tests (mean of the unconditional variables added to each axis). Based on Table 6, column (6).

Country codes: Argentina (ARG), Bolivia (BOL), Brazil (BRA), Chile (CHL), Colombia (COL), Costa Rica (CRI), Ecuador (ECU), Guatemala (GTM), Honduras (HND), Mexico (MEX), Panama (PAN), Peru (PER), Paraguay (PRY), El Salvador (SLV), Uruguay (URY), Venezuela (VEN).

Figure 5: Cognitive skills and economic growth in Latin America and the world



Added-variable plot of a regression of the average annual rate of growth (in percent) of real GDP per capita in 1960-2000 on the initial level of real GDP per capita in 1960, average scores on international student achievement tests, and average years of schooling in 1960 (mean of the unconditional variables added to each axis). Separate regression lines for Latin American (black) and non-Latin American (red) countries.

Table 1: Latin American income and education in a global perspective

	GDP per capita 1960	Growth of GDP per capita 1960-2000	GDP per capita 2000	Years of schooling 1960	Test score
	(1)	(2)	(3)	(4)	(5)
Asia	1,891	4.5	13,571	4.0	479.8
Sub-Saharan Africa	2,304	1.4	3,792	3.3	360.0
Middle East and North Africa	2,599	2.7	8,415	2.7	412.4
Latin America	**4,152**	**1.8**	**8,063**	**4.7**	**388.3**
Europe	7,469	2.9	21,752	7.4	491.5
Commonwealth OECD	11,252	2.1	26,147	9.5	500.3
Note: Asia w/o Japan	*1,614*	*4.5*	*12,460*	*3.5*	*474.7*

Underlying country sample: all countries with internationally comparable data on GDP that ever participated in a worldwide student achievement test; see Hanushek and Woessmann (2009) for details. The country observations contained in the six regions are: Asia (11): China, Hong Kong, India, Indonesia, Japan, Rep. of Korea, Malaysia, Philippines, Singapore, Taiwan, Thailand; Commonwealth OECD members (4): Australia, Canada, New Zealand, USA; Europe (17): Austria, Belgium, Denmark, Finland, France, Greece, Iceland, Ireland, Italy, Netherlands, Norway, Portugal, Romania, Spain, Sweden, Switzerland, United Kingdom; Latin America (7): Argentina, Brazil, Chile, Colombia, Mexico, Peru, Uruguay; Middle East and North Africa (8): Cyprus, Egypt, Iran, Israel, Jordan, Morocco, Tunisia, Turkey; Sub-Saharan Africa (3): Ghana, South Africa, Zimbabwe.

Sources: Own calculations based on Penn World Tables (Heston, Summers, and Aten (2002)); Cohen and Soto (2007); Hanushek and Woessmann (2009).

Table 2: Latin America in worldwide regressions of cognitive skills and economic growth

Unit of observation:	World regions				Countries	
	(1)	(2)	(3)	(4)	(5)	(6)
Test score	2.345***		2.387***		1.980***	0.788
	(16.74)		*(11.10)*		*(9.12)*	*(1.05)*
Years of schooling			-0.050	1.073	0.026	0.009
			(-0.31)	*(1.32)*	*(0.34)*	*(0.12)*
Initial GDP per capita	-0.312***	-0.071	-0.282	-0.821	-0.302***	-0.295***
	(-13.88)	*(-0.49)*	*(-2.75)*	*(-1.41)*	*(-5.54)*	*(-5.41)*
Test score x Not Latin America						1.284
						(1.64)
Latin America						-0.861
						(-1.50)
Constant	-6.185***	2.910**	-6.257**	0.972	2.903***	2.905***
	(-11.18)	*(3.34)*	*(-8.93)*	*(0.58)*	*(28.38)*	*(25.92)*
N	6	6	6	6	50	50
R^2	0.990	0.056	0.991	0.403	0.745	0.760
Adj. R^2	0.983	-0.180	0.976	0.006	0.728	0.733

Dependent variable: average annual growth rate in GDP per capita, 1960-2000. *t*-statistics in parentheses: statistical significance at * 10%, ** 5%, *** 1%. See Table 1 for a list of the six world regions and the countries contained in each, as well as data sources. In the country-level analyses, all variables are mean-subtracted.

Table 3: Cognitive skills and economic growth in Latin America: Evidence from regional achievement tests

	Years of schooling (1)	Years of schooling (2)	LLECE (3)	LLECE (4)	LLECE + SERCE (5)	LLECE + SERCE (6)	LLECE + SERCE (7)
Test score			2.910**	2.669***	0.641**	0.844***	0.546*
			(3.68)	*(5.44)*	*(2.50)*	*(3.46)*	*(2.10)*
Years of schooling	0.377**	0.469*	-0.083		0.225		
	(2.73)	*(1.98)*	*(-0.41)*		*(1.71)*		
Initial GDP per capita	-0.290**	-0.319*	-0.247**	-0.262**	-0.319***	-0.277***	-0.298***
	(-2.88)	*(-2.15)*	*(-2.84)*	*(-3.59)*	*(-3.71)*	*(-3.14)*	*(-3.76)*
Protection against expropriation							0.384*
							(2.08)
Constant	0.938	0.716	-8.161**	-7.536***	-0.556	-0.537	-1.969*
	(1.76)	*(0.77)*	*(-3.31)*	*(-4.18)*	*(-0.74)*	*(-0.67)*	*(-1.98)*
N	16	9	9	9	16	16	16
R^2	0.464	0.504	0.866	0.862	0.647	0.562	0.678
Adj. R^2	0.382	0.339	0.786	0.816	0.559	0.494	0.597

Dependent variable: average annual growth rate in GDP per capita, 1960-2000. *t*-statistics in parentheses: statistical significance at * 10%, ** 5%, *** 1%. See Table A1 for data sources.

Table 4: Cognitive skills and economic growth in Latin America and the world

	(1)	(2)[a]	(3)[a]	(4)[a]
Test score	1.980***	1.999***	1.574***	0.827***
	(9.12)	*(9.22)*	*(10.19)*	*(3.04)*
Years of schooling	0.026	0.022	0.093	0.045
	(0.34)	*(0.29)*	*(1.28)*	*(0.64)*
Initial GDP per capita	-0.302***	-0.303***	-0.318***	-0.312***
	(-5.54)	*(-5.60)*	*(-6.20)*	*(-6.60)*
Test score x Not Latin America				1.178***
				(3.42)
Latin America				-0.714**
				(-2.19)
Constant	2.982***	2.517***	2.616***	2.517***
	(28.75)	*(22.88)*	*(26.44)*	*(19.60)*
N	50	50	59	59
R^2	0.745	0.748	0.750	0.797
Adj. R^2	0.728	0.732	0.736	0.777

Dependent variable: average annual growth rate in GDP per capita, 1960-2000. *t*-statistics in parentheses: statistical significance at * 10%, ** 5%, *** 1%. See Table A1 for data sources. [a] Replacing Latin American scores by regional tests.