The Political Economy of ILSAs in Education: The Role of Knowledge Capital in Economic Growth

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Contents

Abstract

Economic theory suggests that the skills of a society's population are important determinants of economic growth. ILSAs have been used to put these theories to

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an empirical test. This chapter provides an overview of models of the role of educational achievement in macroeconomic outcomes and summarizes empirical economic work using ILSAs to measure relevant skills. In economic terms, the aggregate cognitive skills of the population as measured by ILSAs can be interpreted as the knowledge capital of nations. The chapter concludes that there is strong evidence that the cognitive skills of the population – rather than mere school attainment – are powerfully related to long-run economic growth. The relationship between knowledge capital and growth proves extremely robust in empirical applications. Growth simulations reveal that the long-run rewards to educational quality are large but also require patience.

Keywords

Economic growth · Knowledge capital · Human capital · ILSA · Cognitive skills

Overview

With the passage of the Sustainable Development Goals (SDGs) by the United Nations in 2015, the topic of economic growth became central to worldwide discussion (https://sustainabledevelopment.un.org/sdgs). The 17 separate goals cannot be achieved without strong economic growth that expands the resources available and that permits addressing this range of worthwhile but expensive goals. But achieving strong economic growth is not possible without developing strong human capital in each of the countries. This chapter, which draws on Hanushek and Woessmann (2015a, 2015b), describes what is known about economic growth and how it is affected by strong education programs.

Even in the richest countries, a segment of the population has been left behind to deal with limited resources and limited opportunities. This segment has faced health insecurity, constrained job possibilities, and a myriad of other threats associated with poverty. The difficulties for this group are compounded when countries as a whole lag behind world improvement in economic outcomes.

Sustainable development calls for recognizing the full costs of development. In the past, growth and development have come with costs to the environment. These costs accumulate over time, leading to excessive pressures on the ecosystem that threaten the future. Sustainable development will depend on innovation that permits growth while respecting natural resources.

The key to achieving inclusive and sustainable development lies in increasing the knowledge and skills of populations. Knowledge-led growth, the hallmark of at least the past half century, provides a path that converges on the overall goals of the broader world community. Inclusive development is best pursued through expanded economic opportunities. Simply put, it is much easier to ensure inclusion and to alleviate the burdens of poverty when the whole economic pie is larger. Expanded skills allow a broader segment of society to actively contribute to the economy; this increased participation contributes to enhanced productivity and reduces the redistributive needs. Within a fixed economy, even attempting to redistribute resources is generally politically difficult and may threaten the overall performance of the economy. Expanded skills also facilitate sustainable development and growth because they lead to innovative capacity that allows economic advancement without simultaneously depleting environmental resources.

Without the necessary cognitive skills to compete and thrive in the modern world economy, many people are unable to contribute to and participate in development gains. Literacy was once defined in terms of the ability to read simple words. But in today's global marketplace, it is more. It is the capacity to understand, use, and reflect critically on written information; the capacity to reason mathematically and use mathematical concepts, procedures, and tools to explain and predict situations; as well as the capacity to think scientifically and to draw evidence-based conclusions. Today a substantial fraction of the world's population is functionally illiterate. The functional illiterates do not have the skills that employers seek and that the labor market rewards.

While minimal skills are important for individual participation in modern economies, the discussion here focuses mostly on the aggregate implications of the cognitive skills of a nation's workforce. Where significant proportions of the population have limited skills, economies are generally bound to employ production technologies that lag those in advanced economies. They also have more limited ability to innovate or even to imitate the possibilities that are found near the economic production frontier.

Empirically, as described below, international large-scale assessments (ILSAs) provide useful measures of the cognitive skills that are relevant for growth. Aggregate cognitive skills form the knowledge capital of a nation, and aggregate scores on international tests prove to be good measures of knowledge capital.

The economic evidence indicates that countries with less skilled populations – with less knowledge capital – will find productivity improvements difficult. As a result, they will find economic growth and development to be slower. In addition, what growth there is will be less inclusive because those without minimal skills will be unable to keep pace with their more-skilled peers.

Cognitive skills are of fundamental importance for developing countries. But these skills also matter for advanced countries. Thus development goals built around minimal skills have meaning to all societies around the world. They correct the distorted picture of the challenges facing the world suggested by the original Millennium Development Goals and the Education for All initiative, which framed the issue of education and skills as relevant to developing countries only (https://www.un.org/millenniumgoals/). The challenges have clearly been more severe for less developed economies, but they were and are real for more developed economies as well.

Existing research shows that there has historically been a strong and direct relationship between the cognitive skills of national populations, measured by international tests of mathematics and science achievement, and countries' long-run growth. In fact, ILSAs have provided the data needed to understand the growth process. Moreover, as discussed further below, the evidence in this modern growth analysis provides strong reason to believe that the relationship is causal – i.e., if a nation improves the skills of its population, it can expect to grow faster.

ILSAs of course do not provide a complete view of every country's population. Some countries have not participated in international tests, so they cannot be directly compared with others, although participation in regional tests in Latin America and Africa provides information for a larger set of countries. Further, even in countries that do participate, the proportion of students who have already left school – and who are therefore out of the view of international testing – varies.

The heart of the analysis summarized here offers a concise economic perspective on a primary development goal – bringing all youth up to minimally competitive skills. This fundamental goal emphasizes the importance of skills over mere school attendance. But of course, youth are unlikely to develop appropriate skills without attending school, and the analysis below builds upon the prior development goals related to access. The analysis extends the simple cognitive skills goal to include schooling for all along with minimal skills for all.

The past record on the interplay of cognitive skills and economic growth provides a means of estimating the economic gains from meeting the development goal set out in the SDGs. The economic benefit from meeting SDG #4 ("Ensure inclusive and equitable quality education") can be calculated as the difference in future GDP with universal minimal skills versus GDP with the country's current knowledge capital. Indeed, it is possible to provide these estimates on a country-by-country basis, at least for the 76 countries with current information on their knowledge capital (from ILSAs) and on the state of their aggregate economy.

Understanding Growth

To develop an understanding of the structure of growth, economists have followed two tracks – tracks that are largely separated but that sometimes intersect. On one track is the development of theoretical models that identify specific features and mechanisms of economies and trace their implications for growth over time. On the other track are empirical exercises designed to extract regularities in growth based on the observed differences in outcomes. At times, specific theoretical models drive a particular empirical analysis. At others, the empirical work is more loosely connected to any specific model but is driven more by data and statistical forces.

Invariably, both strands of modern work on growth recognize the importance of human capital. This partly incorporates the insight from the work of Theodore Schultz (1961), Gary Becker (1964), Jacob Mincer (1974), and others since the late 1950s that human capital is important for individual productivity and earnings. But even more, innovation and productivity improvements, while possibly differing in the underlying details, are seen as being fundamentally guided by the underlying invention of people, and invention flows from the knowledge and skills of the population.

The attention here is focused on the measurement of human capital and on how improved measurement alters understanding of some fundamental economic issues.

The historic empirical consideration of human capital focused on school attainment measures of human capital. As demonstrated below, however, it is necessary to transition to broader measures that revolve around cognitive skills.

This section provides an overview of the conceptual underpinnings of the analysis of economic growth. It then turns to the historic empirical analysis before transitioning to the use of ILSAs to measure the knowledge capital of nations.

A Conceptual Framework for Knowledge and Growth

Economists have devoted enormous time and effort to developing and understanding alternative mechanisms that might underlie the growth of nations. Indeed, entire books are written on models of economic growth and their implications. For example, see Acemoglu (2009), Aghion and Howitt (1998, 2009), Barro and Sala-i-Martin (2004); Jones and Vollrath (2013) for introductions. The aim here is simply providing the outlines of competing approaches, because they will have implications not only about how to proceed in empirical work but also about how to interpret any subsequent analyses.

Theoretical models of economic growth have emphasized different mechanisms through which education may affect economic growth. As a general summary, three theoretical models have been applied to the modeling of economic growth, and each has received some support from the data. At the same time, it has been difficult to compare the alternative models empirically and to choose among them based on the economic growth data.

The most straightforward modeling follows a standard characterization of an aggregate production function where the output of the macro economy is a direct function of the capital and labor in the economy. The basic growth model of Solow (1956) began with such a description and then added an element of technological change to trace the movement of the economy over time. The source or determinants of this technological change, although central to understanding economic growth, were not an integral part of that analysis. The so-called augmented neoclassical growth theories, developed by Mankiw, Romer, and Weil (1992), extend this analysis to incorporate human capital, stressing the role of education as a factor of production. Education can be accumulated, increasing the human capital of the labor force and thus the steady-state level of aggregate income. The human capital component of growth comes through accumulation of more education that implies the economy moves from one steady-state level to another. Once at the new level, education exerts no further influence on growth in such a model. The common approach to estimating this model focuses on the level of income and relates *changes* in GDP per worker to *changes* in education (and in capital). This view implies a fairly limited role of human capital, because there are natural constraints on the amount of schooling in which a society will invest. It also fails to explain patterns of education expansion and growth for many developing countries (Pritchett, 2006).

A very different view comes from the so-called endogenous growth literature that has developed over the past quarter century, partly building on the early insight of

Schumpeter (1912[2006]) that growth is ultimately driven by innovation. In this work, a variety of researchers – importantly, Lucas (1988), Romer (1990), and Aghion and Howitt (1998) – stress the role of human capital in increasing the innovative capacity of the economy through developing new ideas and new technologies. These are called endogenous growth models because technological change is determined by economic forces within the model. Under these models, a given level of education can lead to a continuing stream of new ideas, thus making it possible for education to affect long-run growth rates even when no new education is added to the economy. The common way to estimate these models focuses on growth in income and relates *changes* in GDP per worker (or per capita) to the *level* of education.

A final view of human capital in production and growth centers on the diffusion of technologies. If new technologies increase firm productivity, countries can grow by adopting these new technologies more broadly. Theories of technological diffusion such as those developed by Nelson and Phelps (1966), Welch (1970), and Benhabib and Spiegel (2005) stress that education may facilitate the transmission of knowledge needed to implement new technologies. In tests involving cross-country comparisons, Benhabib and Spiegel (1994) found a role for educational attainment in both the generation of ideas and in the diffusion of technology.

All approaches have in common that they see human capital as being a crucial ingredient to growth.

Growth Models with School Attainment

This section provides an overview of economic growth modeling. (Further details can be found in Hanushek and Woessmann (2008), on which this section is based.) The following equation provides a very simple but convenient growth model: a country's rate of economic growth is a function of the skills of workers (human capital) and other factors (initial levels of income and technology, economic institutions, and other systematic factors) and some unmeasured factors, ε.

$$growth = \gamma Human\ \ Capital + \beta Other + \varepsilon \tag{1}$$

Worker skills are best thought of simply as the workers' human capital stock. For expositional purposes, this simple model assumes that there is only one dimension to human capital and that growth rates are linear in these inputs, although these are not really important for the analysis below.

Human capital is nonetheless not directly observed. To be useful and verifiable, it is necessary to specify the measurement of human capital. The vast majority of existing theoretical and empirical work on growth begins – frequently without discussion – by taking the quantity of schooling of workers as a direct measure of human capital. This choice was largely a pragmatic one related to data availability, but it also had support from the empirical labor economics literature. Mincer (1974), in looking at the determinants of wages, demonstrated that years of schooling was an informative empirical measure of differences in individual skills.

In what might be called the standard approach, empirical growth modeling has quite consistently relied on school attainment averaged across the labor force as the measure of aggregate human capital. Early work employed readily available cross-country data on school enrollment rates, which essentially were interpreted as capturing changes in school attainment. An important innovation by Barro and Lee (1993, 2001, 2013) was the development of internationally comparable data on average years of schooling for a large sample of countries and years, based on a combination of census or survey data on educational attainment wherever possible and using literacy and enrollment data to fill gaps in the census data.

Following the seminal contributions by Barro (1991, 1997) and Mankiw et al. (1992), a vast early literature of cross-country growth regressions has tended to find a significant positive association between quantitative measures of schooling and economic growth. To give an idea of the reliability of this association, primary schooling turns out to be the most robust influence factor (after an East Asian dummy) on growth in GDP per capita in 1960–1996 in the extensive robustness analysis by Sala-i-Martin, Doppelhofer, and Miller (2004) of 67 explanatory variables in growth regressions on a sample of 88 countries.

Figure 1 plots the average annual rate of growth in GDP per capita over the 40-year period from 1960 to 2000 against years of schooling at the beginning of the

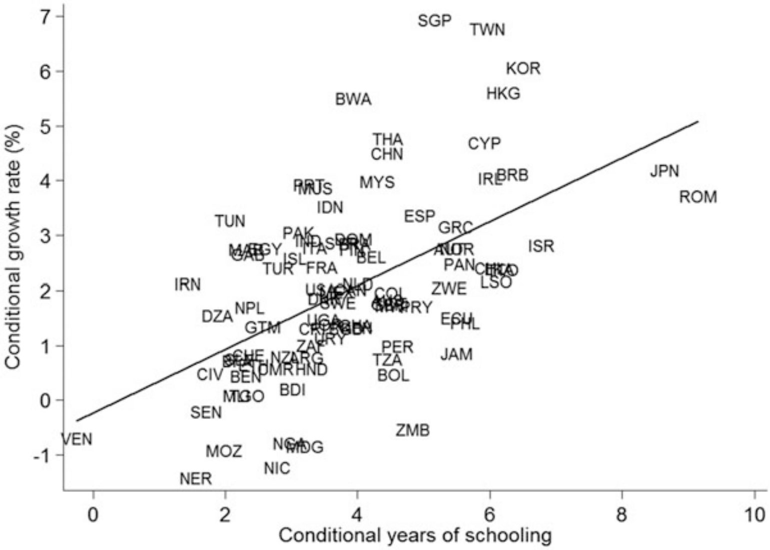

Fig. 1 Years of schooling and economic growth rates without considering knowledge capital. Notes: Added-variable plot of a regression of the average annual rate of growth (in percent) of real GDP per capita in 1960–2000 on average years of schooling in 1960 and initial level of real GDP per capita in 1960 (mean of unconditional variables added to each axis). (Source: Hanushek and Woessmann (2015a))

period for a sample of 92 countries. This figure is based on an underlying regression that also includes the initial level of GDP per capita for each country. Inclusion of this reflects the fact that for countries starting behind, it is easier to grow fast because it is just necessary to copy what is done elsewhere. Countries starting ahead must invent new things and new production methods in order to grow fast, and that is generally more difficult.

The results depicted by the figure imply that each year of schooling is statistically significantly associated with a long-run growth rate that is 0.6 percentage points higher.

There are skeptical studies that raise noteworthy caveats with this depiction. First, Bils and Klenow (2000) raise the issue of causality, suggesting that reverse causation running from higher economic growth to additional education may be at least as important as the causal effect of education on growth in the cross-country association. Second, one of the conclusions that Pritchett (2001, 2006) draws from the fragility of the evidence linking changes in education to economic growth is that it is important for economic growth to get other things right as well, in particular the institutional framework of the economy. Both issues are actually subsumed by better measurement of human capital as discussed next.

An Extended View of the Measurement of Human Capital

Growth models that measure human capital by average years of schooling implicitly assume that a year of schooling delivers the same increase in knowledge and skills regardless of the education system. For example, a year of schooling in Venezuela is assumed to create the same increase in productive human capital as a year of schooling in Singapore. Additionally, this measure assumes that formal schooling is the primary (sole) source of skills and that variations in non-school factors have a negligible effect on education outcomes. This neglect of cross-country differences in the quality of education and in the strength of family, health, and other influences is a major drawback of using the quantitative measure of school attainment to proxy for skills of the labor force in cross-country analyses.

The larger issues can be better understood by considering the source of the skills (human capital). As discussed in the extensive educational production function literature (Hanushek, 2002), these skills are presumed to be affected by a range of factors including family inputs, the quantity and quality of inputs provided by schools, other relevant factors (including labor market experience, health, and so forth), and unmeasured input (ν) as in:

$$Human\ \ Capital = \lambda Family + \phi School\ \ quality + \eta Other + \nu \tag{2}$$

The schooling term is meant to combine both school attainment and its quality. Indeed, there is a broad research base that documents each of the inputs components.

Obviously, if Eq. 2 describes the formation of skills, simply relying on school attainment in the growth modeling is unlikely to provide reasonable estimates of the role of human capital. They will undoubtedly be biased estimates, and they will be sensitive to the exact model specification and to the inclusion of other country measures – exactly what past analysis shows. The complications from the multiple inputs into skills suggest that the alternative is measuring human capital directly.

A compelling alternative is to focus directly on the cognitive skills component of human capital and to measure human capital with test score measures of mathematics, science, and reading achievement. The use of measures of educational achievement, which builds on prior research into both educational production functions and models of economic returns to individuals, has a number of potential advantages. First, achievement captures variations in the knowledge and skills that schools strive to produce and thus relate the putative outputs of schooling to subsequent economic success. Second, by emphasizing total outcomes of education, such measures incorporate 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), they open the investigation of the importance of different policies designed to affect the quality aspects of schools.

Some recent work has introduced the possibility that noncognitive skills also enter into individual economic outcomes (see importantly Bowles, Gintis, and Osborne (2001); Heckman, Stixrud, and Urzua (2006); Cunha, Heckman, Lochner, and Masterov (2006); Borghans, Duckworth, Heckman, and ter Weel (2008); Almlund, Duckworth, Heckman, and Kautz (2011); Lindqvist & Vestman, 2011). Hanushek and Woessmann (2008) integrate noncognitive skills into the interpretation of general models such as the one described here and show how this may affect the interpretation of the parameter on school attainment and other estimates. While there are no agreed-upon measures of noncognitive skills, at the aggregate level they might well be incorporated in "cultural differences." In any event, the lack of cross-country data on these noncognitive factors precludes incorporating them directly into any statistical analyses.

Importantly, for analyzing differences in growth across countries, the range of ILSAs conducted since the mid-1960s offers the possibility of directly comparing skills across countries. While varying numbers of countries have participated in international testing over time, a substantial fraction of countries of the world have participated in international testing at one time or another. For a history of the relevant ILSA for use in growth analysis, see Hanushek and Woessmann (2015a). Unfortunately, until recently, no effort has been made to link the separate tests over time.

While there have been varying regional tests, the two main tests linking countries across regions are TIMSS (Trends in International Mathematics and Science Study) and its predecessors and PISA (Programme for International Student Assessment). Given the different test designs, can results be compared across countries? And can the different tests be aggregated? Interestingly, the TIMSS tests with their curricular focus and the PISA tests with their real-world application focus are highly correlated at the country level. For example, the correlation coefficients between the TIMSS 2003 test of eighth graders and the PISA 2003 test of 15-year-olds across the 19 countries participating in both tests are 0.87 in math and 0.97 in science, and they are 0.86 in both math and science across the 21 countries participating both in the TIMSS 1999 test and the PISA 2000/02 test. There is also a high correlation at the country level between the curriculum-based student tests of TIMSS and the practical adult literacy examinations of IALS (Hanushek & Zhang, 2009). Tests with very different foci and perspectives tend to be highly related, suggesting that they are measuring a common dimension of skills (see also Brown et al., 2007). As discussed below, the consistency lends support to aggregating different student tests for each country in order to develop comparable achievement measures. It is also encouraging when thinking of these tests as identifying fundamental skills included in "knowledge capital."

Comparisons of the difficulty of different ILSA tests across time are readily possible because the United States has participated in all assessments and because there is external information on the absolute level of performance of US students of different ages and across subjects. The United States began consistent testing of a random sample of students around 1970 under the National Assessment of Educational Progress (NAEP). By using the pattern of NAEP scores for the United States over time, it is possible to equate the US performance across each of the international tests. This approach was introduced by Hanushek and Kimko (2000) and was refined by Hanushek and Woessmann (2015a), where a complete discussion of the methodology can be found. In order to get comparable measures of variances across tests, Hanushek and Woessmann (2015a) build on the observed variations of country means for a group of countries that have well-developed and relatively stable educational systems over the time period.

To compare long-term growth across countries, Hanushek and Woessmann (2015a) construct a measure of the knowledge capital of each county by averaging scores across all of the subject and year observations of skills found in TIMSS and PISA. While there are some observed score changes within countries, the overall rankings of countries show considerable stability. For the 693 separate test observations through 2003 in the 50 countries that Hanushek and Woessmann (2015a) employ in their growth analysis, 73 percent of the variance falls between countries. The remaining 27 percent includes both changes over time in countries' scores and random noise from the testing. By averaging, the noise component will be minimized at the cost of obscuring any differences over time for each country.

Knowledge Capital and Growth

The knowledge capital measure from the ILSAs turns out to be very closely related to economic growth rates in cross-country growth regressions. The central part of the analyses discussed here is the direct estimation of Eq. 1. As described in detail in Hanushek and Woessmann (2015a) and summarized here, long-term economic growth rates across all countries with relevant data are regressed on an aggregate compilation of ILSA scores, on initial levels of national income, and on other factors.

Unlike the case in prior empirical growth studies, the clearest result here is the consistency of the alternative estimates of the cognitive skills-growth relationship – both in terms of quantitative impacts and statistical significance. (For a sense of the instability surrounding early empirical analyses, see the evaluations in Levine and Renelt (1992) and Levine and Zervos (1993).) The remarkable stability of the models in the face of alternative specifications, varying samples, and alternative measures of cognitive skills implies a robustness uncommon to most cross-country growth modeling (Hanushek & Woessmann, 2015a). In terms of previous questions about the fragility of any estimates of years of schooling and growth, these estimates underscore a simple finding that prior results suffered from critical measurement issues.

The central finding of the statistical analysis is the importance of cognitive skills in explaining international differences in long-run growth rates (growth over the period 1960–2000). Table 1 from Hanushek and Woessmann (2015a) presents basic results from a 50-country sample. While not the focal point of this analysis, all specifications include GDP per capita in 1960, which provides consistent evidence for conditional convergence, i.e., countries with lower initial income tend to grow faster. The sample includes all countries with both prior ILSA results and reliable historical data on GDP. As a comparison to prior cross-country analyses, the first column of Table 1 presents estimates of a simple growth model with school attainment – the model underlying Fig. 1 above, estimated on the 50-country sample. While this model explains one-quarter of the variance in growth rates, adding cognitive skills increases this to three-quarters of the variance. The aggregate test score from the ILSAs is strongly significant with a magnitude that is unchanged by whether initial school attainment in 1960 is excluded (column 2) or included (column 3).

Table 1 Years of schooling vs. cognitive skills in growth regressions

	(1)	(2)	(3)
Cognitive skills		2.015***	1.980***
		(10.68)	*(9.12)*
Initial years of schooling (1960)	0.369***		0.026
	(3.23)		*(0.34)*
Initial GDP per capita (1960)	−0.379***	−0.287***	−0.302***
	(4.24)	*(9.15)*	*(5.54)*
Constant	2.785***	−4.827***	−4.737***
	(7.41)	*(6.00)*	*(5.54)*
No. of countries	50	50	50
R^2 (adj.)	0.252	0.733	0.728

Source: Hanushek and Woessmann (2015a)

Notes: Dependent variable: average annual growth rate in GDP per capita, 1960–2000. Cognitive skill measure refers to average score on all international tests 1964–2003 in math and science, primary through end of secondary school. *t*-statistics in parentheses: statistical significance at *10%, **5%, ***1%

Figure 2 provides a graphical depiction of the basic results (and depictions that are essentially unchanged by the subsequent investigations of alternative specifications). Figure 2 plots the independent impact of knowledge capital on growth, based on column 3 of the table. In contrast to the earlier picture of the impact of school attainment on growth (Fig. 1), countries are now seen lying quite close to the overall line, indicating a very close relationship between educational achievement and economic growth.

It is also instructive to plot the impact of school attainment on growth *after considering cognitive skills*. As seen in Fig. 3, the relationship is now flat: School attainment is not statistically significant in the presence of the direct cognitive skill measure of knowledge capital. This does not change when attainment is measured as the average between 1960 and 2000, rather than at the beginning of the period.

The insignificance of school attainment, of course, does not mean that schooling is irrelevant. Measured skills are closely related to schooling, but life cycle skill accumulation depends upon the learning earlier in life. Achievement here is measured at various points during primary and secondary education. Even if tertiary education is simply additive, knowledge at earlier points in education will strongly influence the ultimate skill accumulation when students enter the labor force. As James Heckman and his colleagues have emphasized, there is a dynamic complementarity of investments such that further schooling has a larger impact on skills if it builds on a larger base developed earlier (Cunha & Heckman, 2007). The simple

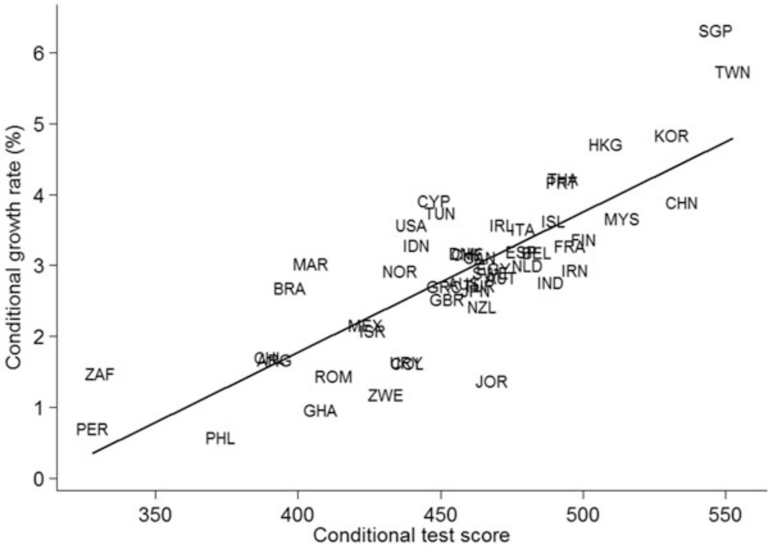

Fig. 2 Knowledge capital and economic growth rates across countries. Notes: Added-variable plot of a regression of the average annual rate of growth (in percent) of real GDP per capita in 1960–2000 on average test scores on international student achievement tests, average years of schooling in 1960, and initial level of real GDP per capita in 1960 (mean of unconditional variables added to each axis). (See Table 1, column 3. Source: Hanushek and Woessmann (2015a))

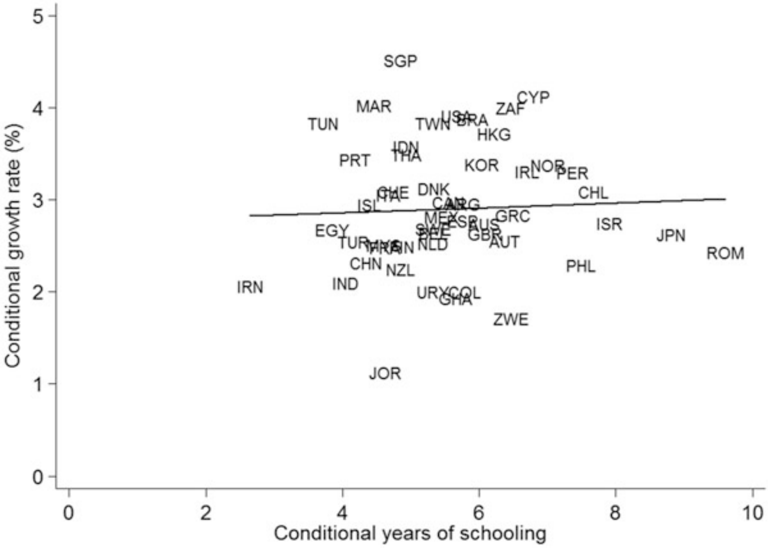

Fig. 3 Years of schooling and economic growth rates after considering knowledge capital. Notes: Added-variable plot of a regression of the average annual rate of growth (in percent) of real GDP per capita in 1960–2000 on average years of schooling in 1960, average test scores on international student achievement tests, and initial level of real GDP per capita in 1960 (mean of unconditional variables added to each axis). See Table 1, column 3. (Source: Hanushek and Woessmann (2015a))

point is that "skill begets skill through a multiplier process" (Cunha et al., 2006), p. 698), such that additional attainment has a lessened impact if built upon lower basic skills. The insignificance of school attainment does suggest that simply investing in further schooling without ensuring commensurate improvements in cognitive skills does not lead to economic returns.

Relatedly, a variety of people place extra weight on tertiary education (e.g., Ehrlich, 2007). However, without building on strong basic skills, such investment appears to have little extra value. Hanushek and Woessmann (2015a) find that in analysis of growth across both developed and developing countries, tertiary education has little added value in explaining economic growth after consideration of cognitive skills with the exception that US investments in higher education have signaled increased growth. See also Hanushek (2016).

It is useful to consider the magnitude of the estimated impact of knowledge capital on growth. This is amplified below with country-specific estimates of growth impacts. Following a general convention, skill differences are measured in terms of standard deviations, where one standard deviation is, for example, the difference between the median student and the student at the 84th percentile of the international distribution. Almost all of the alternative specifications and modeling approaches suggest that one standard deviation higher cognitive skills of a country's workforce is associated with approximately *two percentage points higher annual growth in* per capita *GDP.*

This magnitude is clearly substantial, particularly when compared to growth rates that average between 1.4 and 4.5 percent over the 1960–2000 period across broad regions. On the other hand, it is implausible to expect a country to improve by one standard deviation – bringing, say, Mexico up to the OECD average – over any reasonable time horizon. But it is plausible to think of getting schooling improvements that would lift a country's average by ¼ standard deviation (25 points on a PISA scale). This kind of improvement has, for example, been observed by Mexico, Poland, Germany, and Turkey during the past decade and by Finland over the two to three decades before (see Organisation for Economic Co-operation and Development, 2013). The economic impact of such differences are considered below.

Perhaps a leading competitor as a fundamental explanation of growth differences is the role of societal institutions – including the basic economic and legal structure of nations. This perspective, pursued importantly by Daron Acemoglu and his collaborators, links growth to some of the overall policies of countries. See, for example, the overview and discussion in Acemoglu, Johnson, and Robinson (2005) and Acemoglu and Robinson (2012). This perspective is actually quite complementary to the work described here. Hanushek and Woessmann (2015a) show that knowledge capital has a statistically significant and strong (albeit somewhat smaller) impact on growth when explicit institutional measures are included.

A final issue addressed by Hanushek and Woessmann (2015a) is that the simple average of skills does not adequately reflect the policy options typically facing a nation. Specifically, one could institute policies chiefly directed to the lower end of the cognitive distribution, such as the Education for All initiative, or one could aim more at the top end, such as the focused technological colleges of India. It is possible to go beyond simple mean differences in scores and provide estimates of how growth is affected by the distribution of skills within countries and how it might interact with the nation's technology. These estimates in Hanushek and Woessmann (2015a) suggest that improving both ends of the distribution is beneficial and complementary, i.e., the importance of highly skilled people is even larger with a more skilled labor force. Perhaps surprisingly, the highly skilled are even more important in developing countries that have scope for imitation than in developed countries that are innovating. In other words, both providing broad basic education – education for all – *and* pushing significant numbers to very high achievement levels have economic payoffs.

Causality

The fundamental question is whether the tight relationship between cognitive skills and economic growth should be interpreted as a causal one that can support direct policy actions? In other words, if achievement were raised, should one really expect growth rates to go up by a commensurate amount? Hanushek and Woessmann (2012, 2015a, 2015b) devote considerable attention to causality, and it is valuable to consider the strengths and weaknesses of those analyses. While the details of the analyses become complicated, it is possible to bring out the ideas from these discussions.

Work on differences in growth among countries, while extensive over the past two decades, has been plagued by legitimate questions about whether any truly causal effects have been identified, or whether the estimated statistical analyses simply pick up a correlation that emerges for other reasons.

Knowing that the relationship is causal, and not simply a byproduct of some other factors, is clearly very important from a policy standpoint. Policymaking requires confidence that by improving academic achievement, countries will bring about a corresponding improvement in the long-run growth rate. If the relationship between test scores and growth rates simply reflects other factors that are correlated with both test scores and growth rates, policies designed to raise test scores may have little or no impact on the economy.

The early studies that found positive effects of years of schooling on economic growth may well have been suffering from reverse causality; they correctly identified a relationship between improved growth and more schooling but incorrectly saw the latter as the cause and not the effect (see, e.g., Bils & Klenow, 2000). In this case, the data may have reflected the fact that as a country gets richer, it tends to buy more of many things, including more years of schooling for its population.

There is less reason to think that higher student achievement is caused by economic growth. For one thing, scholars have found little impact of additional education spending on achievement outcomes, so it is unlikely that the relationship comes from growth-induced resources lifting student achievement (see the review in Hanushek and Woessmann (2011)). Still, it remains difficult to develop conclusive tests of causality with the limited sample of countries included in the analysis.

The best way to increase confidence that higher student achievement causes economic growth is to consider explicitly alternative explanations of the observed achievement-growth relationship to determine whether plausible alternatives that could confound the results can be ruled out. No single approach can address all of the important concerns. But a combination of approaches – if together they provide support for a causal relationship between achievement and growth – can offer some assurance that the potentially problematic issues are not affecting the results.

First, other factors besides cognitive skills may be responsible for countries' economic growth. In an extensive investigation of alternative model specifications, Hanushek and Woessmann (2015a) employ different measures of cognitive skills, various groupings of countries (including some that eliminate regional differences), and specific sub-periods of economic growth. But the results show a consistency in the alternative estimates, in both quantitative impacts and statistical significance, that is uncommon in cross-country growth modeling. Nor do measures of geographical location, political stability, capital stock, and population growth significantly affect the estimated impact of cognitive skills. These specification tests rule out some basic problems attributable to omitted causal factors that have been noted in prior growth work.

Second, the most obvious reverse causality issues arise because the analysis reported above from Hanushek and Woessmann (2015a) relates growth rates over the period 1960–2000 to test scores for roughly the same period. To address this directly, it is possible to separate the timing of the analysis and to estimate the effect of test scores through 1984 on economic growth in the period since 1985 (until 2009). This analysis capitalizes directly on the long history of ILSAs. In this analysis, available for a sample of 25 countries only, test scores strictly pre-date the growth period, making it clear that increased growth could not be causing the higher test scores. This estimation shows a positive effect of early test scores on subsequent growth rates that is almost twice as large as that displayed above. Indeed, this fact itself may be significant, because it is consistent with the possibility that skills have become even more important for the economy in recent periods.

Third, even if reverse causality were not an issue, it remains unclear that the important international differences in test scores reflect school policies. After all, differences in achievement may arise because of health and nutrition differences in the population or simply because of cultural differences regarding learning and testing. To address this, it is possible to focus attention on just the variations in achievement that arise directly from institutional characteristics of each country's school system (exit examinations, autonomy, relative teacher salaries, and private schooling). The formal approach is called "instrumental variables." (In order for this to be a valid approach, it must be the case that the institutions are not themselves related to differences in growth beyond their relation with test scores. For a fuller discussion, see Hanushek and Woessmann (2012). When the analysis is limited in this way, the estimation of the growth relationship yields essentially the same results as previously presented. The similarity of the results supports the causal interpretation of the effect of cognitive skills as well as the conclusion that schooling policies can have direct economic returns.

Fourth, a possible alternative to the conclusion that high achievement drives economic growth not eliminated by the prior analysis is that countries with good economies also have good school systems. In this case, achievement is simply a reflection of other important aspects of the economy and not the driving force in growth. One simple way to test this possibility is to consider the implications of differences in measured skills within a single economy, thus eliminating institutional or cultural factors that may make the economies of different countries grow faster. This can readily be done by comparing immigrants to the United States who have been educated in their home countries with immigrants educated just in the United States. Since the two groups are within the single labor market of the United States, any differences in labor market returns associated with cognitive skills cannot arise from differences in the economy or culture of their home country. This comparison finds that the cognitive skills seen in the immigrant's home country lead to higher incomes, but only if the immigrant was in fact educated in the home country. Immigrants from the same home country schooled in the United States see no economic return to home country test scores – a finding that pinpoints the value of better schools. These results hold when Mexicans (the largest US immigrant group) are excluded and when only immigrants from English-speaking countries are included. While not free from problems, this comparative analysis rules out the possibility that test scores simply reflect cultural factors or economic institutions of the home country. It also lends further support to the potential role of schools in changing the cognitive skills of citizens in economically meaningful ways.

Finally, perhaps the toughest test of causality is relating *changes* in test scores over time to *changes* in growth rates. If test score improvements actually increase growth rates, it should show up in such a relationship. For those countries that have participated in testing at different points over the past half century, it is possible to observe whether students seem to be getting better or worse over time. This approach implicitly eliminates country-specific economic and cultural factors because it looks at what happens over time within each country. For 12 OECD countries that have participated over a long time, the magnitude of trends in educational performance can be related to the magnitude of trends in growth rates over time. This investigation provides more evidence of the causal influence of cognitive skills (although the small number of countries is obviously problematic). The gains in test scores over time are very closely related to the gains in growth rates over time. Like the other approaches, this analysis must presume that the pattern of achievement changes has been occurring over a long time, because it is not the achievement of school children but the skills of workers that count. Nonetheless, the consistency of the patterns is striking, as is the similarity in magnitude of the estimates to the basic growth models.

Again, each approach to determining causation is subject to its own uncertainty. Nonetheless, the combined evidence consistently points to the conclusion that differences in cognitive skills lead to significant differences in economic growth. Moreover, even if issues related to omitted factors or reverse causation remain, it seems very unlikely that these cause *all* of the estimated effects.

Since the causality tests concentrate on the impact of schools, the evidence suggests that school policy, if effective in raising cognitive skills, can be an important force in economic development. While other factors – culture, health, and so forth – may affect the level of cognitive skills in an economy, schools clearly contribute to the development of human capital. More years of schooling in a system that is not well designed to enhance learning, however, will have little effect.

The Gains from Universal Basic Skills

A simple way to assess the importance of knowledge capital is to look at the potential impacts that can be related to improved knowledge capital of nations according to historical growth patterns. One simple example is a version of the Sustainable Development Goal related to education: equitable provision of quality education at least through primary and lower secondary school. Projections that can be developed from the PISA testing provide an image of the potential gains around the world from improved education.

The Global Challenge

Looking at the 15-year-old population of different countries (which matches the age of testing in PISA), it is possible to understand both variations in school attainment and in quality for a large number of countries of the world. While much of the discussion of education quality focuses on average test scores for countries, it is perhaps better to focus on lower achievement in order to relate such analysis to the minimal goals outlined in the SDGs.

There is reason to be concerned about the number of countries that have yet to ensure broad access to and enrollment in secondary schools. Figure 4 displays net enrollment rates at the tested age for each of the 76 countries in the test sample. (See Hanushek and Woessmann (2015b) for a description of the sample of countries and of the underlying data.) While 44 of the countries have over 95 percent participation of their 15-year-olds in 2012, the participation rates begin to fall significantly after this point. In the bottom 17 countries, enrollment rates are less than 80 percent.

The meaning of quality education, of course, is subject to considerable discussion and debate. A convenient starting point to illustrate the economic impact of

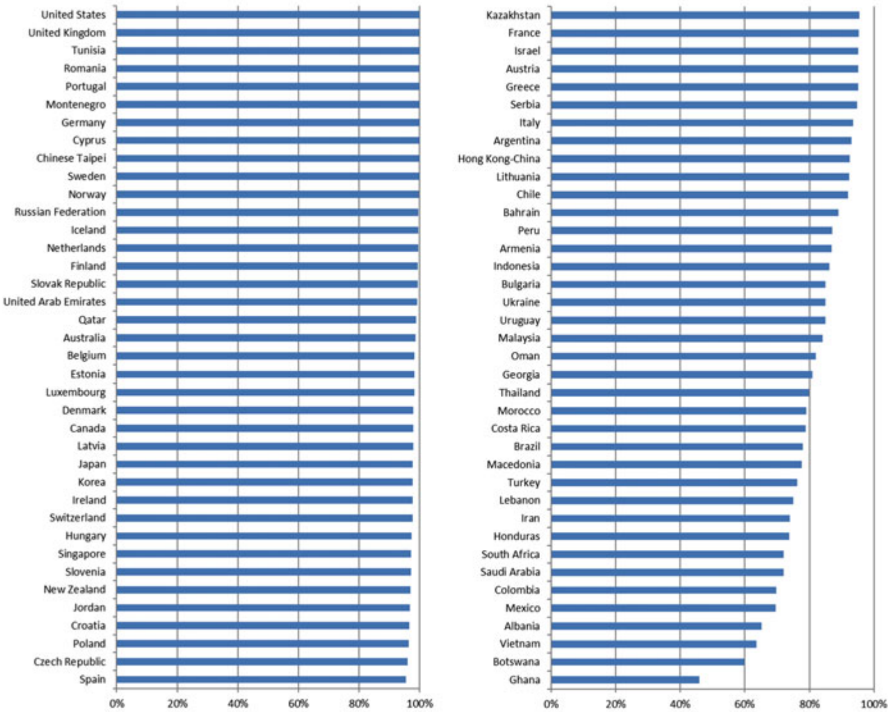

Fig. 4 Secondary school enrolment rates. Notes: PISA participants: share of 15-year-olds enrolled in school; TIMSS (non-PISA) participants: net enrolment ratio in secondary education (% of relevant group). (Source: Hanushek and Woessmann (2015b))

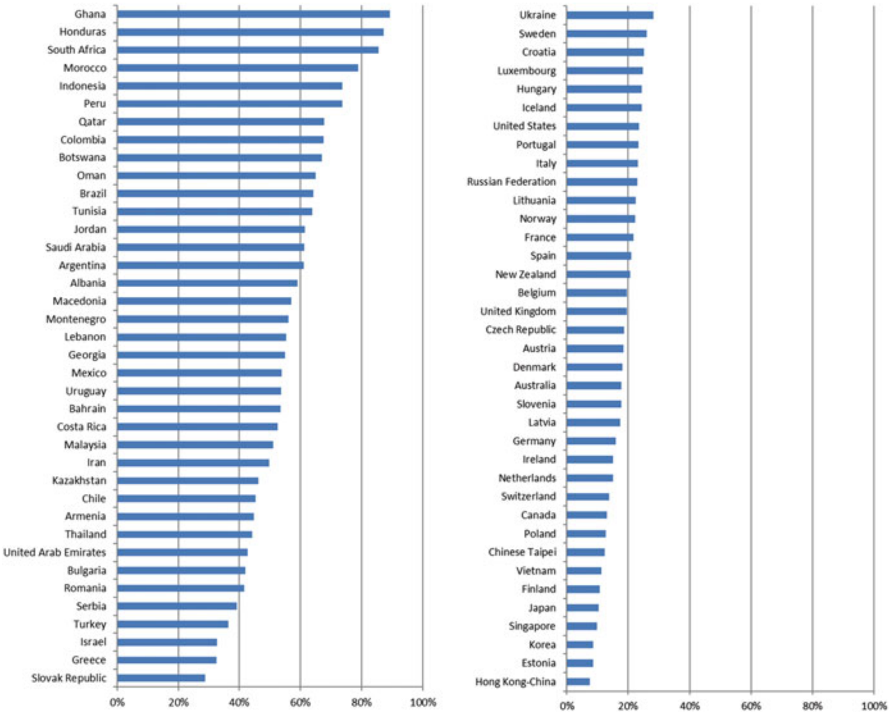

Fig. 5 Share of students not attaining basic skills. Notes: Share of students performing below 420 points on international student achievement test. Average of mathematics and science. PISA participants: based on PISA 2012 micro data; TIMSS (non-PISA) participants: based on eighth-grade TIMSS 2011 micro data, transformed to PISA scale. (Source: Hanushek and Woessmann (2015b))

improvement is to define minimal performance as satisfying Level 1 on the PISA tests. The description of this performance level (for math) is:

> At Level 1, students can answer questions involving familiar contexts where all relevant information is present and the questions are clearly defined. They are able to identify information and to carry out routine procedures according to direct instructions in explicit situations. They can perform actions that are almost always obvious and follow immediately from the given stimuli. (OECD, 2013)

This skill level might be interpreted as the minimal level for somebody to participate effectively in the modern global economy.

Figure 5 presents for the 76 countries the share of youth in school falling below the level indicating minimal skills – below 420 on the mathematics and science assessments on the PISA tests. Figure 5 is of course closely related to what would be seen for average country scores, though in fact the rankings are somewhat different. Nine of the 76 countries have more than two-thirds of their students failing to meet this level of minimum skills (Ghana, Honduras, South Africa, Morocco, Indonesia, Peru, Qatar, Colombia, and Botswana).

Hong Kong, Estonia, Korea, and Singapore lead at the other end of the distribution, but even these countries face the challenge of ensuring that all youth attain minimal skill levels. It is important to recognize that the richest countries of the world also have significant populations without minimal skills: Luxemburg (25 percent), Norway (22 percent), United States (24 percent), and Switzerland (14 percent). In other words, the development goal is significant and real for all the countries of the world.

Economic Impacts of Universal Basic Skills

It is possible to use the previously displayed growth model (Table 1) to estimate the economic impact of improving the education picture seen in Figs. 4 and 5. Specifically, the growth relationships found in Table 1 provide a means of simulating how growth and thus future GDP would be altered if a country altered its knowledge capital. Schooling policies obviously take time to have their effect on the labor force and on future growth, but various school improvements can be traced out – assuming that the past relationships hold into the future.

Hanushek and Woessmann (2015b) provide alternative projections based on reforms beginning in 2015; these include meeting the SDG #4 goal. The education development goal is framed as the standard that should be met by 2030, making their assumption of linear improvement from today's schooling situation to attainment of the goal in 15 years natural. But of course the labor force itself will only become more skilled as increasing numbers of new, better trained people enter the labor market and replace the less skilled who retire. If a typical worker remains in the labor force for 40 years, the labor force will not be made up of fully skilled workers until 55 years have passed (15 years of reform and 40 years of replacing less skilled workers as they retire).

They calculate the growth rate of the economy (according to the estimate of 1.98 percent higher annual growth rate per standard deviation in educational achievement; see column 3 of Table 1) each year into the future based on the average skill of workers (which changes as new, more skilled workers enter). The expected level of gain in GDP with an improved workforce comes from comparing GDP with a more skilled labor force to that with the existing workforce from 2015 until 2095. The growth of the economy with the current level of skills is projected to be 1.5 percent or the rough average of OECD growth over the past two decades. The projection is carried out for 80 years, which corresponds to the life expectancy of somebody born in 2015.

Future gains in GDP are discounted from the present with a 3 percent discount rate. The initial GDP refers to 2015 estimates based on purchasing-power-parity (PPP) calculations in current international dollars; see International Monetary Fund (2014). The resulting present value of additions to GDP is thus directly comparable to the current levels of GDP. It is also possible to compare the gains to the discounted

Table 2 Gains from achieving universal basic skills

	In % of current GDP	In % of discounted future GDP
Lower middle-income countries	1302%	27.9%
Upper middle-income countries	731%	15.6%
High-income non-OECD countries	473%	10.1%
High-income OECD countries	162%	3.5%

Source: Hanushek and Woessmann (2015b)
Notes: Discounted value of future increases in GDP until 2095 due to a reform that achieves full participation in secondary school and brings each student to a minimum of 420 PISA points. Simple averages of countries in each income group

value of projected future GDP without reform to arrive at the average increase in GDP over the 80 years.

Table 2 summarizes the projected gains for each of the groupings of countries under an assumption that each country achieves universal basic skills of its students by 2030. Unsurprisingly, the lowest-income countries of the sample would show by far the largest gains. The simple estimates for the eight lower middle-income countries indicate a present value of gains averaging 13 times the current GDP of these countries. Translated into a percentage of future GDP, this implies a GDP that is 28 percent higher on average every year for the next 80 years. By the end of the projection period in 2095, GDP with school improvement would average some 140 percent greater than would be expected with the current skills of the labor force.

Increases of this magnitude are, of course, unlikely, because the projected gains in achievement over the next decade and a half are outside any real expectations. Ghana and Honduras, for example, would require an increase in achievement of over one standard deviation during this 15-year period. Nothing like that has ever been seen. But the calculations do show the value of improvement and suggest the lengths to which a country should be willing to go to improve its schools.

Figure 6 compares the gains from meeting universal basic skills (in present value terms) to current GDP. Perhaps the most interesting part of the figure is the right-hand side. It shows that among the high-income non-OECD countries, the impact on the oil-producing countries is particularly dramatic. Improved minimal skills among the populations of Oman, Qatar, and Saudi Arabia imply gains exceeding eight times current GDP for these countries, and Bahrain follows closely. If the price of oil falls, say through new technologies, these countries will have to rely on the skills of their populations – and the data suggest there is substantial room for improvement.

Equally interesting are the high-income OECD countries, which typically don't figure in discussions of development goals. For 8 of these 31 countries, the present value of GDP gains from meeting the minimal skills goal would be more than twice the size of their current GDP. In order, OECD countries with gains exceeding twice GDP are Chile, Israel, the Slovak Republic, Greece, Italy, France, Sweden, and Luxemburg. The average gain across the high-income OECD countries is 162 percent of current GDP. This implies a GDP that is on average 3.5 percent higher than would be expected with no improvement in the schools (see Fig. 7). Almost all of the gain comes from improving achievement at the bottom end, since enrollment in these

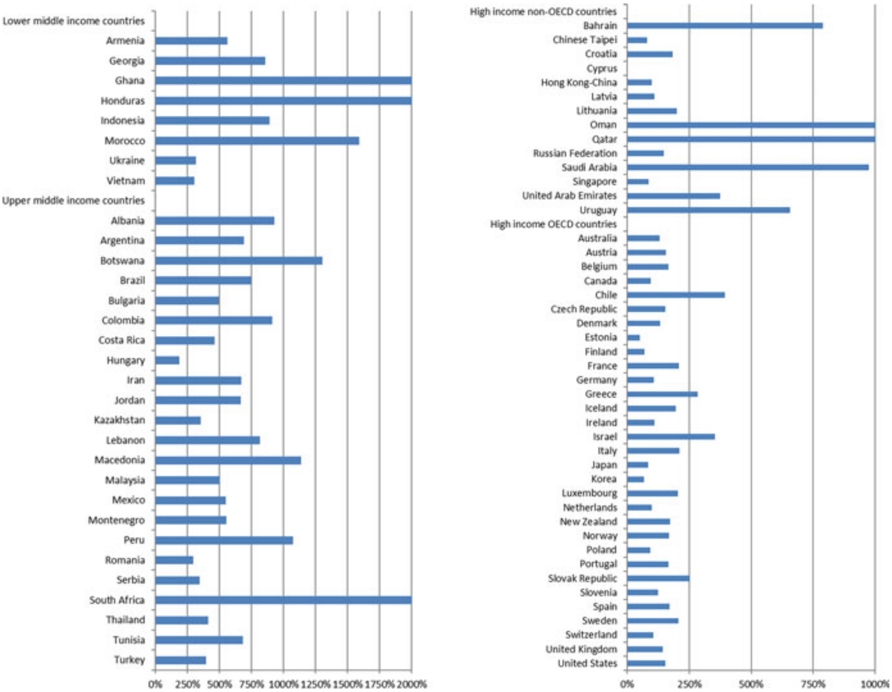

Fig. 6 Effect on GDP if all children acquire basic skills (in % of current GDP). Notes: Discounted value of future increases in GDP until 2095 simulated for each country based on the growth models in Table 1, column 3. The simulations assumed a 15-year school reform that achieves full participation in secondary school and brings each student to a minimum of 420 PISA points, expressed as a percentage of current GDP. Value is 3881% for Ghana, 2016% for Honduras, 2624% for South Africa, 1427% for Oman, and 1029% for Qatar. (Source: Hanushek and Woessmann (2015b))

countries is near universal. The lowest secondary enrollment rates among high-income OECD countries are found in Chile (92 percent), Italy (94 percent), Greece (95 percent), and France (95 percent).

Interestingly, particularly given the international debates on educational goals, the impact of improving student quality is almost always larger than the impact of improving access at current quality levels of each nation. The alternative scenarios are found originally in Hanushek and Woessmann (2015b). Figure 8 shows the economic gains (in terms of percent of future GDP) for three alternative improvements: (1) achieving basic skills just for those currently in school; (2) expanding access to school for all with current quality levels; and (3) achieving universal basic skills. Even for the lower middle-income countries, improving quality completely dominates just having full access. Of course, doing both is significantly better than pursuing either partial option.

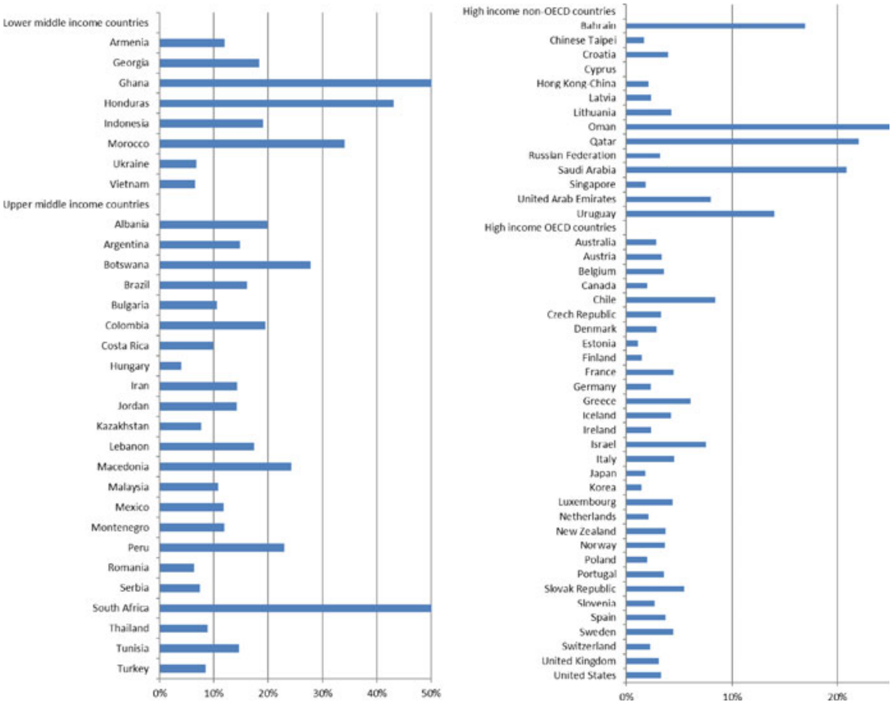

Fig. 7 Effect on GDP if all children acquire basic skills (in % of discounted future GDP). Notes: Discounted value of future increases in GDP until 2095 simulated for each country based on the growth models in Table 1, column 3. The simulations assumed a 15-year school reform that achieves full participation in secondary school and brings each student to a minimum of 420 PISA points, expressed as a percentage of discounted future GDP. Value is 83.0% for Ghana, 56.1% for South Africa, and 30.5% for Oman. (Source: Hanushek and Woessmann (2015b))

Conclusions

The implicit message of this chapter is that ILSAs provide particularly relevant data for considering economic development issues. ILSAs permit direct comparisons of the skills of the citizens across a broad range of countries.

Development goals in education are generally easy to motivate both within individual countries and within international development agencies because there is ready acceptance of the idea that nations' growth is directly related to human capital – the skills of the populations. The disappointments have come largely from an undue focus on school attainment as opposed to learning. Historically, by relying on measured years of school attainment to assess progress toward educational goals, success was more apparent than real. Over the past two decades, school attainment in developing countries has grown significantly, but learning has not grown commensurately.

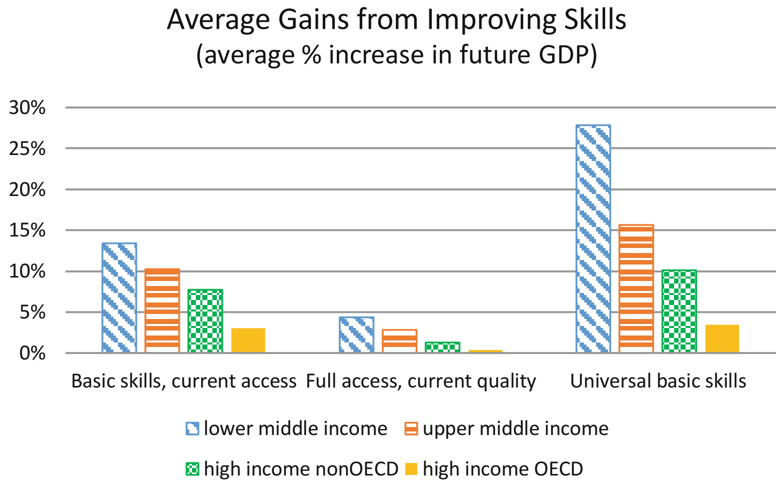

Fig. 8 Average gains for countries at different income levels from improving skills. Notes: Average improvements across countries by income groups of the simulations underlying Fig. 7 except done separately for three separate reforms: 1. Bring all students currently in school to basic skill levels; 2. ensuring access to all children at the current quality level of the schools; and 3. bringing all students up to basic skill level. (Source: Hanushek and Woessmann (2020))

The results reported here build on prior work that focuses on the gains from learning and that supports the finding of a strong, causal relationship between cognitive skills and economic growth. The Sustainable Development Goals indicate that a fundamental education goal for all nations can be succinctly stated: all youth should achieve minimal skills. We suggest that a workable definition of minimal skills in today's economically competitive world is fully mastering Level 1 skills on the PISA tests, which is equivalent to a mathematics score of 420. Importantly, this quality aspect of the education goal can be readily measured and tracked, thus providing a similar impetus to development than the prior focus on attainment did.

The history of economic growth makes understanding the economic implications of different educational policy outcomes straightforward. Three options that represent much of current policy discussion can be readily compared: bringing all current students up to minimal skills; universal access to schools at current quality; and universal access with minimal skills.

Universal access at current quality yields some economic gains, particularly in the lower-income countries. But improving the quality of schools to raise achievement for current students has a much larger economic impact. Meeting the goal of universal access with basic skills for all has an even greater impact. For lower middle-income countries, the discounted present value of future gains would be 13 times the current GDP and would average out to a 28 percent higher GDP over the next 80 years. For upper middle-income countries, it would average out to a 16 percent higher GDP.

The goal of universal minimal skills also has meaning for high-income countries. Driven in part by oil-producing countries that face some schooling challenges, the high-income non-OECD countries as a group would see an average of 10 percent higher future GDP – almost five times the value of current GDP – if they met this goal. But even the high-income OECD countries would gain significantly from bringing all portions of the population up to basic skills; for this group, future GDP would be 3.5 percent higher than it would be otherwise. Improving the skills of the population clearly has substantial implications for economic well-being, in particular when improvements that accrue in the more distant future are also considered.

Cross-References

- ▶ Educational Accountability and the Role of International Large-Scale Assessments
- ▶ Methods of Causal Analysis with ILSA Dat
- ▶ The Role of International Large Scale Assessments (ILSAs) in Economically Developing Countries
- ▶ Using ILSAs to Promote Quality and Equity in Education

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