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GDP Projections

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Introduction

We model a country's growth rate as a function of the skills of workers and other factors that include initial levels of income and technology, economic institutions, and other systematic factors. Skills are frequently referred to simply as the workers' human capital stock.

$$growth = \alpha_1 \; human\ capital + \alpha_2 \; other\ factors + \varepsilon \qquad (1)$$

This formulation suggests that nations with more human capital tend to continue to make greater productivity gains than nations with less human capital.

The empirical macroeconomic literature focusing on cross-country differences in economic growth has overwhelmingly employed measures related to school attainment, or years of schooling, to test the human capital aspects of growth models and has tended to find a significant positive association between quantitative measures of schooling and economic growth. Average years of schooling is, however, a particularly incomplete and potentially misleading measure of education for comparing the impacts of human capital on the economies of different countries. It implicitly assumes 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 South Africa is assumed to create the same increase in productive human capital as a year of schooling in Korea. Additionally, formulations relying on this measure assume that formal schooling is the primary (sole) source of education and that variations in non-school factors have negligible effects on education outcomes and skills. This neglect of cross-country differences in the quality of education and in the strength of family, health, and other influences is probably the major drawback of such a quantitative measure of schooling.

Our analysis relies on the measures of cognitive skills developed in Hanushek and Woessmann (2009). Between 1964 and 2003, twelve different international tests of math, science, or reading were administered to a voluntarily participating group of countries (see Hanushek and Woessmann (2011) for a review). These include 36 different possible scores for year-age-test combinations (e.g., science for students of grade 8 in 1972 as part of the First International Science Study or math of 15-year-olds in 2000 as a part of the Programme on International Student Assessment). The assessments are designed to identify a common set of expected skills, which were then tested in the local language. Each test is newly constructed, until recently with no effort to link to any of the other tests. Hanushek and Woessmann (2009) describe the construction of consistent measures across tests at the national level across countries through empirical calibration of the different tests. By transforming the means and variances of the original country scores (partly based on external longitudinal test score information available for the United States), each is placed into a common distribution of outcomes. Each age group and subject is normalized to the PISA standard of mean 500 and individual standard deviation of 100 across OECD countries, and then all available test scores are aggregated to the country level. We interpret the test scores as an index of the human capital of the populations (and workforce) of each country.

Our cross-country regressions of economic growth follow an expanding literature which, over the past ten years, demonstrates that consideration of cognitive skills dramatically alters the assessment of the role of education and knowledge in the process of economic development. Hanushek and Woessmann (2009) extend the empirical analysis to incorporate 50 countries that have participated in one or more international testing occasions between 1964 and 2003 and have aggregate economic data for the period 1960-2000.

We estimate this model is two different forms. In the first, we regress the average annual growth rate from 1960-2000 for GDP per capita on initial income level (GDP per capita in 1960), school attainment in 1960, and cognitive skills measured by average international test scores. In the second, instead of average test scores, we use measures of the tails of the distribution – the percentage of students scoring at least 400 points (one standard deviation below the OECD mean of 500) and the percentage scoring greater than 600 points (one standard deviation above the OECD mean of 500).

The basic estimates used for our projections are shown in Table 1.

Overview of Projections

The economic projections involve several components. First, we calculate the time path of the annual growth rate engendered by education reform designed to move students from their current performance to a given new level. This pattern of economic outcomes represents the confluence of three separate dynamic processes: (1) Changes in schools lead to the progressive improvement in student achievement until students fully reach the new steady-state level of achievement; (2) students with better skills move into the labor force and the average skills of workers increase as new, higher achieving workers replace retiring workers; and (3) the economy responds to the progressive improvement of the average skill level of the workforce. Second, based on the pattern of predicted growth rates, we model the future development of GDP with and without the education reform. Third, based on these projections, we calculate the total value of the reform by aggregating the discounted values of the annual differences between the GDP with reform and the GDP without reform.

For the purposes here, reforms are assumed to take 20 years to complete, and the path of increased achievement during the reform period is taken as linear. For example, an average improvement of 25 points on PISA is assumed to reflect a gain in the student population of 1.25 points per year. This might be realistic, for example, when the reform relies upon a process of upgrading the skills of teachers – either by training for existing teachers or by changing the workforce through replacement of existing teachers. This linear path dictates the quality of new cohorts of workers at each point in time.

The expected work life is assumed to be 40 years, which implies that each new cohort of workers is 2.5 percent of the workforce. Thus, even after an educational reform is fully implemented, it takes 40 years until the full labor force is at the new skill level.

The benchmark here considers all economic returns that arise during the lifetime of a child that is born at the beginning of the reform in 2010. According to the most recent data (that refer to 2006), a simple average of male and female life expectancy at birth over all OECD countries is 79 years (Organisation for Economic Co-operation and Development (2009c)). Therefore, the baseline calculations take a time horizon until 2090, considering all future returns that accrue until then, but neglecting any returns that accrue after 2090.

Finally, more immediate benefits are both more valuable and more certain than those far in the future. In order to incorporate this, the entire stream is converted into a present discounted value. In simplest terms, the present discounted value is the current dollar amount that would be equivalent to the future stream of returns calculated from the growth model. If we had that amount of funds and invested it today, it would be possible to reproduce the future stream of economic benefits from the principal amount and the investment returns. Thus, this calculation of present discount value allows a relevant comparison for any other current policy actions.

In doing so, the discount rate at which to adjust future benefits becomes an important parameter. A standard value of the social discount rate used in long-term projections on the sustainability of pension systems and public finance is 3 percent (e.g., Börsch-Supan (2000), Hagist, Klusen, Plate, and Raffelhüschen (2005)), a precedent that is followed here. By contrast, the influential Stern Review report that estimates the cost of climate change uses a discount rate of only 1.4 percent, thereby giving a much higher value to future costs and benefits (Stern (2007)).

A number of untested assumptions go into the projections. First, they assume that skills play the same role in the future as they have in the past, so that the evidence of past results provides a direct way to project the future. Second, while the statistical analysis did not look at how economies adjust to improved skills, the calculations assume that the experience of other countries with greater cognitive skills provide the relevant insight into how the new skills will be absorbed into the economy. Third, the projection of simultaneous improvement across countries presumes that all countries can grow faster without detracting from (or benefiting) growth in other countries. In other words, the higher levels of human capital in each country allow it to innovate, to improve its production, and to import new technologies without detracting from the growth prospects for other countries. Further, the estimates ignore any other aspects of interactions such as migration of skilled labour across borders. (Of course, one way that a country could improve its human capital would be by arranging for its youth to obtain schooling in another country with better schools – as long as the more educated youth return to their home country to work). Fourth, all countries are assumed to have a stationary population with a constant age distribution. Finally, all calculations are in real (inflation-adjusted) terms – 2010 dollars under purchasing power parity.

Details of Projections

The economic impact of reform varies across four phases that are defined by the average quality of the labor force. The reform plan we project has several distinct phases defined by the composition of the work force in each year over the 80 year period.

a) Phase 1 (2010-2030): During the 20 years of the education reform program, the additional growth in GDP per capita due to the reform in year *t* is given by:

$$\Delta^t = growth\ coefficient * \Delta PISA * \frac{1}{working\ life} * \frac{t-2010}{20} + \Delta^{t-1} \qquad (3)$$

where the *growth coefficient* comes from the regression estimations presented in the previous sections and Δ*PISA* is the increase in the average PISA test score due to the reform. (In the range of projections we also consider a ten-year reform program; i.e., a program that reaches the new achievement levels in just 10 years instead of the 20 years described here). The working life term indicates that each cohort of new, higher achieving students is only a fraction of the total labor force.

b) Phase 2 (2031-2050): The education reform is now fully enacted, and achievement of all subsequent students remains at the new level. But for the length of a work life from the start of reform, which in the baseline simulations is assumed to last 40 years, there are still workers with initial levels of skills that are being replaced in retirement by higher achieving workers. During this phase, the additional growth in GDP per capita in year *t* due to the reform is given by:

$$\Delta^t = growth\ coefficient * \Delta PISA * \frac{1}{working\ life} + \Delta^{t-1} \qquad (4)$$

c) Phase 3 (2051-2070): During this phase, the first 20 labor-market cohorts – which only partially profited from the education reform – are replaced by cohorts that profited from the fully enacted education reform:

$$\Delta^t = growth\ coefficient * \Delta PISA * \frac{1}{working\ life} - \left(\Delta^{t-40} - \Delta^{t-41}\right) + \Delta^{t-1} \qquad (5)$$

d) Phase 4 (after 2070): Finally, the whole workforce has gone through the reformed education system. The annual growth rate is now increased by the constant long-run growth effect Δ:

$$\Delta = growth\ coefficient * \Delta PISA \qquad (6)$$

The level of GDP with and without reform

a) Without reform, the economy grows at the constant growth rate of potential GDP:

$$GDP^t_{no\ reform} = GDP^{t-1}_{no\ reform} * \left(1 + potential\ \ growth\right) \qquad (7)$$

b) With reform, the annual growth rate is additionally increased by the growth effect Δ^t:

$$GDP_{reform}^{t} = GDP_{reform}^{t-1} * \left(1 + potential\ \ growth + \Delta^{t}\right) \qquad (8)$$

Results of Projections

The results are displayed in Table 2. We show the overall results for eight separate reform paths. Specifically we have a more modest and more aggressive reform plan for each of the goals (change in average performance and improvement at the bottom end). We also in each instance consider a 20-year and a 10-year reform path.

The most modest reform plan would call for improving average performance by 25 points (PISA equivalent) or one-quarter standard deviation, and it would do this improvement over a 20 year period. As Table 2, this "modest" reform would yield additions to GDP over the next 80 years that were worth over 300 percent of current GDP. An aggressive program of 50 point improvement over 20 years would have a present value of 664 percent of current GDP.

The programs of improvement at the bottom end of the achievement distribution also have large gains in the economy. A 20 percent improvement in the proportion of students reaching level 1 (i.e., reaching 400 PISA points) would yield higher GDP equal to 342 percent of current GDP even with a 20 year reform program. With a 10-year reform, the gains would be over four times current GDP.

Table 2 also suggests how long run growth will change with improved achievement. At the low end of the table, a 25-point improvement in scores will lead to ½ percent higher annual growth – enormous amount when compounded over the lifetime of somebody born today.

Conclusions

Past history suggests the possibility of enormous gains in aggregate economic outcomes from improving student learning. The improvements in GDP come from the relationship between learning and growth of an economy. The simple idea embodied in the models is that a better educated workforce is consistent with productivity gains and greater innovation, and these have huge impacts on the future well-being of society.

Table 1: Cognitive Skills as Determinant of Growth of Income per Capita, 1960-2000

	(1)	(2)
GDP per capita 1960	-0.302	-0.287
	(5.54)	(5.12)
Years of schooling 1960	0.026	0.022
	(0.34)	(0.28)
Test score (mean)	1.980	
	(9.12)	
Share of students above threshold of 400		2.732
		(3.61)
Share of students above threshold of 600		12.880
		(4.35)
Constant	-4.737	1.335
	(5.54)	(2.97)
N	50	50
R^2 (adj.)	0.728	0.719

Dependent variable: average annual growth rate in GDP per capita, 1960-2000. *t*-statistics in parentheses.

Table 2. Present Value of future gains relative to current GDP

	Speed of reform:		Change in long-run growth rate
	20 years	10 years	(independent of duration of reform)
+25 points on PISA	308%	375%	0.50%
+50 points on PISA	664%	815%	0.99%
+20 percent more at 400 points	342%	417%	0.55%
+75 percent more at 400 points	1634%	2048%	2.05%