

EDUCATION AND DEVELOPMENT

# Knowledge capital, growth, and the East Asian miracle

Access to schools achieves only so much if quality is poor

By Eric A. Hanushek<sup>1\*</sup> and Ludger Woessmann<sup>2</sup>

With per-capita gross domestic product (GDP) growing by an average of 4.5% annually since 1960, people in East Asia are about nine times as prosperous as two generations ago. By contrast, the average person in Latin America is only about two and a half times as prosperous. Over the past quarter-century, both theoretical and empirical analyses of possible drivers of the different growth rates seen around the world invariably assign an important role to human capital (1–4). This has led to development policies focused on increasing enrollment and retention in schools. We argue, however, that too much attention is paid to the time spent in school, and too little is paid to the quality of the schools and the types of skills developed there.

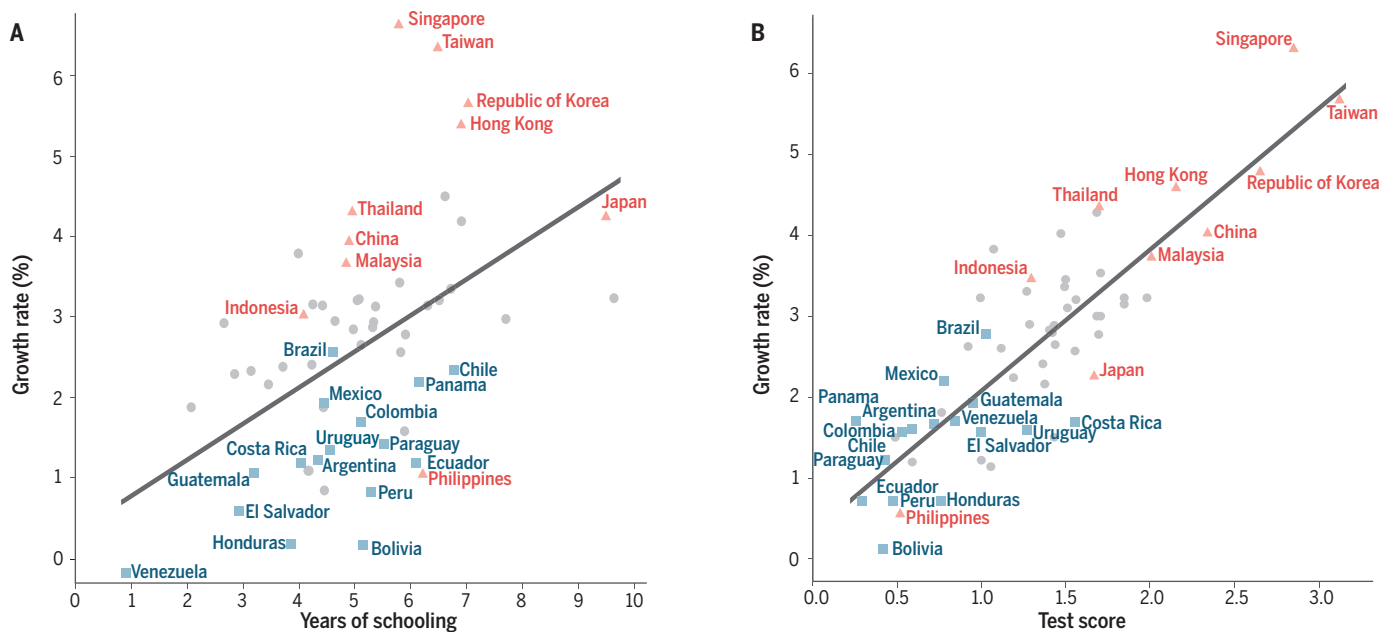
Differences in school attainment cannot account for the East Asian miracle or the Latin American puzzle. When plotting the marginal effect of years of schooling attained in 1960 (5, 6) against annual growth rates between 1960 and 2000 [see the chart, (A)], East Asian countries are systematically above the schooling-growth line, which indicates that they grew faster than expected by their school attainment. Latin American countries, lying below the line, grew slower than expected. [Details of all analyses are in the supplementary materials (SM).]

Empirical analyses of growth have attempted to deal with these and other anomalies by adding geographic, institutional, and cultural factors in addition to school attainment and by taking different approaches to the form and estimation of the models. Nonetheless, skepticism about the validity of such estimates has grown because the impact of various factors has been sensitive to the specification of the model (7), because of sus-

picion of reverse causality, i.e., growth causes more schooling rather than the other way around (8), and because other factors, such as culture or institutions, may drive both schooling and growth (9).

Our prior analysis (10–12) emphasizes linkage between growth and the skills of the population measured by cognitive tests and shows that the main questions about empirical growth models are greatly lessened once skills are appropriately measured. Here, we build upon that work to demonstrate how the apparent growth anomalies mentioned above are consistent with this perspective, and we sketch implications for current development policy.

**MEASURING SKILLS.** Measuring a nation’s human capital by school attainment suffers from two major problems: (i) the assumption that the amount of learning associated with each year of schooling is the same across the world; (ii) the assumption that other factors affecting human capital development—families, health, and the like—are either unimportant or uncorrelated with school attainment. On the surface, neither is plausible. On international math and science tests given at around 9th grade, Honduras lags Singapore by some 2.3 standard deviations (13), which suggests that the average 9th-grade student in Honduras is more than 6 years behind the aver-



**Knowledge capital accounts for apparent growth mysteries in East Asia and Latin America.** (A) Differences in years of school attainment cannot account for either the strong East Asian growth or the weak Latin American growth. (B) Differences in average math and science test scores can account for both phenomena. Both figures refer to the average annual rate of growth of real GDP per capita in 1960–2000, conditional to the initial level of real GDP per capita (both panels, which reflects that countries that start behind can grow faster because it is easier to imitate than to innovate) and to initial years of school attainment (B only). We stop the analysis in 2000 to avoid potential bubbles building up before the 2008 global recession, as well as its aftermath, but results are similar when extended to 2007 or 2009. Each point represents one of the 59 countries for which both economic outcomes over time and international test scores are available. Test score refers to the natural exponential function of the average math and science scores on international tests between 1964 and 2003. Lines are lines of best fit based on a linear regression of the depicted conditional variables. See SM for details. [Source (14)]

age 9th-grade student in Singapore.

We combine all available results for each country from international math and science tests taken between 1964 and 2003 (extended with Latin American regional tests) into a single direct measure of human capital [see SM], which, in the aggregate, we call the knowledge capital of a nation. Our work provides an approach for aggregating scores across previously unintegrated tests (14). This combines skills developed in schools and also in families, among peers, and through cultures.

The importance of more appropriately measuring skills is seen in the chart (B). The knowledge capital-growth relationship suggests little mystery for East Asia, Latin America, or other regions: Growth rates are accounted for by cognitive skills.

Four things stand out from underlying regressions of GDP growth involving years of schooling and test scores (table S2). (i) Cognitive skills are highly related to growth—in terms of both magnitude and statistical significance. (ii) In the presence of the achievement measure, school attainment has no independent effect on growth. (iii) The growth in East Asia and Latin America and the impact of knowledge capital are no different from that in the rest of the world. (iv) Considering knowledge capital dramatically increases our ability to account for differences in growth. A regression including years of schooling accounts for 25% of the variance in country growth rates, compared with 79% when test scores are included.

Although it is impossible to erase all concerns about causality in empirical growth models, the most commonly raised issues can be plausibly addressed. A detailed analysis of causation can be found in (14), but it is useful to summarize the range of tests. Perhaps the most obvious issue is that achievement is measured over the same period as growth. This is motivated by the fact that nations' test outcomes have not changed much over time, with 73% of the variation in test scores reflecting overall country differences as opposed to measurement errors or changes over time (SM). However, it opens the possibility of simple reverse causation. Nevertheless, tests are available since 1964 for 25 countries. If achievement tested before 1985 is related to subsequent growth to 2000 (or 2009), a stronger relation is found for countries with early tests.

Moreover, analyses show that the strong estimated impact of knowledge capital is insensitive to the addition of commonly suggested alternative factors, including geog-

raphy, institutions, and physical capital; to the specific set of countries; or to the precise time period of study (14). Considering merely variations in cognitive skills due to school institutions (such as use of school exit exams or the degree of school choice and competition) shows the same impact on growth as the overall difference in scores and also suggests that school policy matters.

We also investigate labor market performance of immigrants to the United States to rule out the possibility that the knowledge capital-growth relationship reflects a nation's culture or other institutions (14). Cognitive skills that immigrants to the United States are estimated to bring from their home country have direct rewards in the U.S. labor market, whereas immigrants from the same countries schooled in the United States are not rewarded according to the knowledge capital of the home country, which suggests independence of any home country institutions or culture. Finally, we find that the observed

---

### ***“Gains from providing... universal...basic skills are projected to be six times those of just providing universal access to schools.”***

changes in test scores over time are related to changes in growth rates over time (14). These tests with consistent results about the knowledge capital-growth relationship, although not separately conclusive, make a prima facie case that this truly is a causal relationship.

**REORIENT POLICY.** These results have direct implications for policy discussions around the world. Clearly, many factors in addition to schools enter into achievement levels, including parental inputs, health, and preschool programs, but schools offer one important place where public policy can improve the situation.

School-quality issues are clearly important for the United States (15, 16), which currently falls 29th in the world in terms of scores on the Programme for International Student Assessment (PISA) mathematics and science tests. But the implications are strongest for developing countries. For more than two decades, there has been a concerted effort to expand access to schooling in developing countries with the United Nations Millennium Development Goals (MDGs) and the Education for All initiative of the United Nations Organization for Education, Science, and Culture, the World Bank, and others. Both efforts called for all children to com-

plete primary schooling beginning in 2015—something not accomplished.

There has been substantial expansion of schooling under the MDGs; e.g., primary school enrollment in sub-Saharan Africa went up from 60% in 2000 to 80% in 2015 (17). But without a quality focus, the levels of achievement remained incredibly low (18). The MDG experience suggests that going to school without learning has no impact on economic outcomes.

A new set of post-2015 Sustainable Development Goals has recently been established, again focusing on school completion, acknowledging the importance of school quality, but stopping short of quantified quality targets. Lower-income countries (with available test data) generally average only 80% enrollment in lower secondary schools. Projections based on the presented growth model indicate that GDP gains from lifting just the 80% currently enrolled children to basic skill levels are three times the gains from enrolling 100% of children in schools of current quality (13). Gains from providing both universal access and basic skills for all are projected to be six times those of just providing access. If there is going to be inclusive economic development across the world, attention must focus on school quality and having all students achieve basic skills. ■

#### REFERENCES AND NOTES

1. R. J. Barro, *Q. J. Econ.* **106**, 407 (1991).
2. P. Romer, *Carnegie-Rochester Conf. Ser. Public Policy* **32**, 251 (1990).
3. D. Acemoglu, *Introduction to Modern Economic Growth* (Princeton Univ. Press, Princeton, NJ, 2009).
4. P. Aghion, P. Howitt, *The Economics of Growth* (MIT Press, Cambridge, MA, 2009).
5. The measure “years of schooling” is constructed from national census data on completion rates of education levels weighted by the typical length of each level for individual countries. [For details, see SM and (6).]
6. R. J. Barro, J. W. Lee, *Education Matters: Global Schooling Gains from the 19th to the 21st Century* (Oxford Univ. Press, Oxford, 2015).
7. R. Levine, D. Renelt, *Am. Econ. Rev.* **82**, 942 (1992).
8. M. Bils, P. J. Klenow, *Am. Econ. Rev.* **90**, 1160 (2000).
9. D. Acemoglu, S. Johnson, J. A. Robinson, in *Handbook of Economic Growth*, P. Aghion, S. N. Durlauf, Eds. (North Holland, Amsterdam, 2005), vol. 1A, pp. 385–472.
10. E. A. Hanushek, D. D. Kimko, *Am. Econ. Rev.* **90**, 1184 (2000).
11. E. A. Hanushek, L. Woessmann, *J. Econ. Lit.* **46**, 607 (2008).
12. E. A. Hanushek, L. Woessmann, *J. Econ. Growth* **17**, 267 (2012).
13. E. A. Hanushek, L. Woessmann, *Universal Basic Skills: What Countries Stand to Gain* (Organization for Economic Co-operation and Development, Paris, 2015).
14. E. A. Hanushek, L. Woessmann, *The Knowledge Capital of Nations: Education and the Economics of Growth* (MIT Press, Cambridge, MA, 2015).
15. E. A. Hanushek, P. E. Peterson, L. Woessmann, *Endangering Prosperity: A Global View of the American School* (Brookings Institution Press, Washington, DC, 2013).
16. J. I. Klein, C. Rice, J. Levy, *U.S. Education Reform and National Security* (Council on Foreign Relations, Washington, DC, 2012).
17. United Nations, *The Millennium Development Goals Report 2015* (United Nations, New York, 2015).
18. L. Pritchett, *The Rebirth of Education: Schooling Ain't Learning* (Center for Global Development, Washington, DC, 2013).

#### SUPPLEMENTARY MATERIALS

www.sciencemag.org/content/351/6271/344/suppl/DC1

10.1126/science.aad7796

<sup>1</sup>Stanford University, Stanford, CA 94305, USA. <sup>2</sup>Ifo Institute and Ludwig Maximilians University Munich, 80539 Munich, Germany. \*Corresponding author. E-mail: hanushek@stanford.edu