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ABSTRACT

Attention to the quality of human capital in different countries naturally leads to concerns about how school policies relate to student performance. The data from the Third International Mathematics and Science Study provide a way of comparing performance in different schooling systems. The results of analyses of educational production functions within a range of developed and developing countries show general problems with the efficiency of resource usage similar to those found previously in the United States. These effects do not appear to be dictated by variations related to income level of the country or level of resources in the schools. Neither do they appear to be determined by school policies that involve compensatory application of resources. The conventional view that school resources are relatively more important in poor countries also fails to be supported. (Contains 65 references.) (SM)

Efficiency and Equity in Schools around the World

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April 2002

Abstract

Attention to the quality of human capital in different countries naturally leads to concerns about how school policies relate to student performance. The data from the Third International Mathematics and Science Study (TIMSS) provide a way of comparing performance in different schooling systems. The results of analyses of educational production functions within a range of developed and developing countries show general problems with the efficiency of resource usage similar to those found previously in the United States. These effects do not appear to be dictated by variations related to income level of the country or level of resources in the schools. Neither do they appear to be determined by school policies that involve compensatory application of resources. The conventional view that school resources are relatively more important in poor countries also fails to be supported.

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Efficiency and Equity in Schools around the World

By Eric Hanushek and Javier Luque

The emphasis on human capital policy that has become a centerpiece of government programs around the world is now accepted as a natural and enlightened view of policy. Important contributions by Theodore Shultz, Gary Becker, and Jacob Mincer set the case for the importance of human capital for individual productivity and earnings, for the distribution of economic success, and ultimately for the growth of national economies. The implications of this work has been extended into the developing world by a strong and consistent focus of the World Bank – propelled in large part by a series of influential studies by George Psacharopoulos. This work builds on that, considering what countries can do to improve the human capital of their populations.

The central focus is how systematic policy actions of governments affect student performance. Building upon the testing and surveys of the Third International Mathematics and Science Study (TIMSS), we consider specifically how families and schools contribute to within and between country variations in student performance. We then go beyond this to investigate whether school in the different countries work to narrow or widen performance differences.

School quantity and quality

Empirical work in human capital has concentrated on the private returns to the quantity school obtained by individuals. The standard Mincer formulation shows how investment can be translated into observed differences across individuals (Mincer (1970, 1974)). If investment declines linearly and if all of the costs of investment are forgone earnings, the simple relationship between log earnings and years of schooling yields a direct estimate of the rate of return on a year of schooling. This elegant characterization has the overwhelming virtue that it can be applied using commonly available data not only for the United States but many countries of the world. In fact, the exploitation of this generalizability provides clear information about the importance of variations in returns of schooling around different regions of the world (Psacharopoulos (1973, 1981, 1985, 1994)).

The arguments behind government involvement differ somewhat from those for individuals. Indeed, a general finding that the returns to schooling are high does not necessarily mean that this is an area for governmental intervention. Intervention is typically justified by some sort of market failure (such as externalities or credit constraints) or by other goals such as adjusting the income distribution. In fact, at least for the U.S., education has long been thought of as a tool for providing skills to disadvantaged individuals in order to improve their income outcomes. Much of the support for schooling policies internationally also reflects potential gains in terms of the income distribution.

Recent arguments have also provided other support for government interventions based on externalities emanating from the growth process. The general endogenous growth model suggests that the level of education in the economy affects a nation's growth.[1] This structure induces an externality that individuals will not take into account in their own decision process.

Empirical work has underscored the importance of quantity of schooling in these areas.[2] The strongest and most consistent support comes for the relationship between schooling and individual earnings. While relying on more limited evidence, considerable support also exists for the importance of schooling in affecting the distribution of earnings and growth.

The central feature of this analysis, however, is how quality of schooling enters. Nobody believes that all schools within a country or across countries are the same in terms of knowledge

[1] The endogenous growth models come a variety of forms; see Nelson and Phelps (1966), Romer (1986, 1990), and Rebelo (1991).

[2] Some controversy still exists about the form of growth models and about the importance of endogenous growth models. A variety of approaches have been used to test the underlying models, but important questions remain. See Mankiw, Romer, and Weil (1992); Benhabib and Spiegel (1994); Barro and Sala-I-Martin (1995); Bils and Klenow (2000).

imparted and quality in general. Such differences, while often difficult to deal with, have obvious implications for understanding the basic issues addressed here.

The economic effects of differences in the quality of graduates of our elementary and secondary schools are much less understood than the effects of quantity, particularly with regard to the performance of the aggregate economy. The incomplete understanding of the effects of educational quality clearly reflects difficulties in measurement. Although quality of education is hard to define precisely, we mean the term quality to refer to the knowledge base and analytical skills that are the focal point of schools. Moreover, to add concreteness to this discussion, we will tend to rely on information provided by standardized tests of academic achievement and ability. Relying on standardized tests to provide measures of quality is controversial—in part because of gaps in available evidence and in part because of the conclusions that tend to follow (as discussed below).[3] Nevertheless, such measures appear to be the best available indicators of quality and do relate to outcomes that we care about.

A variety of studies of the labor market focus directly on how individual differences in cognitive ability affect earnings (and modify the estimated returns to quality).[4] The most recent direct investigations of cognitive achievement have suggested substantial labor market returns to measured individual differences in cognitive achievement. For example, Bishop (1989, 1991), O'Neill (1990), Grogger and Eide (1993), Murnane, Willett, and Levy (1995), Neal and Johnson (1996), Currie and Thomas (2000), and Murnane et al. (2000) each find that the earnings

[3]A substantial part of the controversy relates to the implications for effectiveness of expenditure or resource policies, as discussed below. The contrasting view emphasizes measuring "quality" by the resources (i.e., inputs) going into schooling. Most recent along this line is Card and Krueger (1992a); see also the reviews of the discussion in Burtless (1996) and Betts (1996).

[4] The early work was subsumed under the general topic of "ability bias" in the returns to schooling. In that, the simple question was whether the tendency of more able individuals to continue in school led to an upward bias in the estimated returns to school (because of a straightforward omitted variables problem). See, for example, Griliches (1974) or Hanushek (1973). More recently, see Blackburn and Neumark (1993, 1995) and Taber (2001). The correction most commonly employed was the inclusion of a cognitive ability or cognitive achievement measure in the earnings function estimates. While focusing on the estimated returns to years of schooling, these studies generally indicated relatively modest impacts of variations in cognitive ability after holding constant quantity of schooling.

advantages to higher achievement on standardized tests are quite substantial. These results are derived from quite different approaches. Bishop (1989) worries about the measurement errors that are inherent in most testing situation and demonstrates that careful treatment of that problem has a dramatic effect on the estimated importance of test differences. O'Neill (1990), Bishop (1991), Grogger and Eide (1993), and Neal and Johnson (1996) on the other hand, simply rely upon more recent labor market data along with more representative sampling and suggest that the earnings advantage to measured skill differences is larger than that found in earlier time periods and in earlier studies (even without correcting for test reliability). Currie and Thomas (2000) provide evidence for a sample of British youth and rely on a long panel of representative data. Murnane, Willett, and Levy (1995), considering a comparison over time, demonstrate that the results of increased returns to measured skills hold regardless of the methodology (i.e., whether simple analysis or error-corrected estimation). Murnane et al. (2000) provides further evidence of the effects of cognitive skills (although offers some caution in the interpretation of strength of effects)

An additional part of the return to school quality comes through continuation in school. There is substantial evidence that students who do better in school, either through grades or scores on standardized achievement tests, tend to go farther in school (see, for example, Dugan (1976); Manski and Wise (1983). Rivkin (1995) finds that variations in test scores capture a considerable proportion of the systematic variation in high school completion and in college continuation. Indeed, Rivkin (1995) finds that test score differences fully explain black-white differences in schooling. Bishop (1991) and Hanushek, Rivkin, and Taylor (1996) find that individual achievement scores are highly correlated with school attendance. A significant portion of the effect of early test scores on closing the black-white income gap in Neal and Johnson (1996) comes through the relationship of achievement on subsequent school attainment. Behrman et al. (1998) find strong achievement effects both on continuation into college and on quality of college; moreover, the effects are larger when proper account is taken of the endogeneity of achievement. Hanushek and Pace (1995), using the High School and Beyond data, find that college completion is significantly related to higher test scores at the end of high school.

This work, while less complete than might be desired, leads to a conclusion that variations in cognitive ability, as measured by standardized tests, are important in career success. Variation in measured cognitive ability is far from everything that is important, but it is significant in a statistical and quantitative sense.

The linkage of individual cognitive skills to aggregate productivity growth has been more difficult to establish. There is no clear consensus on the underlying causes of improvements in the overall productivity of the United States economy, nor on how the quality of workers interacts with economic growth. The analysis of the impact of schooling quality on cross-country differences in growth by Hanushek and Kimko (2000), however, suggests that quality may be very important and could even dominate effects of the quantity of schooling differences across countries. The concern in such work is the direction of causality. While a series of specification tests indicates that there is a causal relationship between quality and growth, the exact magnitude of the effect is open to question.

The available evidence suggests that human capital quality is important. Quality measured by cognitive achievement tests directly influences individual and aggregate productivity. Moreover, at least through the growth mechanism and through the redistributive goals of government, externalities point to a natural role for government. But, even if the evidence on externalities were ignored, governments around the world are the primary supplier of educational services. Thus, without having to answer questions about the rational for action, it is clear that the efficiency and equity of governmental supply are important public policy issues.

Resources and measurement

An important issue throughout the discussions of school quality has been the relationship between outcome measures of quality (earnings, test scores, and the like) and the resources devoted to schools. This issue has two facets. First, when direct quality measures are generally not available, can simple measures of the resources devoted to schools be used as a substitute for a quality measure? Second, if government is to intervene, can it do effectively so by altering the level and distribution of resources going to schools?

Most of the research attention has actually gone to the latter issue – the relevance of resources as a policy tool. On that score the U.S. evidence has been reasonably clear. The resources devoted to schools are not closely or consistently related to student outcomes. While there has been some controversy over this analysis, the data indicate that a minority of studies finds significant and positive relationships with performance.[5]

The general structure of the production function estimation designed to pinpoint causality has focused on a model such as:

$$\mathbf{O} = f(\mathbf{X}, \mathbf{R}) \qquad (1)$$

Where **O** is student outcomes, **R** is a vector of school resources, and **X** is a vector of other inputs into schooling including, importantly, family background of students. The analysis of causal mechanisms has been focused on separating the various inputs into student performance.

The proxy question – i.e., whether measures of resources are an indicator of quality differences regardless of the mechanism – has been looked at separately, although there is

[5] For discussions of the basic results of estimation of the effects of resources, see Hanushek (1986, 1997). For discussions of the controversies, see Hedges, Laine, and Greenwald (1994), Greenwald, Hedges, and Laine (1996) and Hanushek (1996).

obvious overlap. In this collection, other studies have looked at just the simple resource-outcome relationship. While these have not been systematically reviewed in the way that the studies identifying causal factors have, they appear to give somewhat stronger support, at least in the United States, to the proxy relationship.[6] This stronger relationship could simply reflect a positive relationship between resources and other factors such as might arise if wealthier parents on average both contribute more directly to performance and put more resources into their schools.

In the growth setting, there is no direct evidence of the proxy relationship. The attempts to look at resources tended to give incorrect signs and to be poor proxies (Hanushek and Kimko (2000)).

Empirical work on quality in an international setting has, however, been even rarer than in the United States. Few international data sets have had information on outcomes and resources, although – when available – there seems to be slightly stronger relationships of resources and outcomes in the production function setting of equation 1 (Heyneman and Loxley (1983); Hanushek (1995); Vignoles et al. (2000)). When these data have been available, it has been difficult to summarize because the data sets have tended to be very specialized and to be very different across studies. And, little is known about the value of proxy relationships across countries.

International resource-quality estimates

The primary objective of this work is to provide a consistent set of estimates for educational production functions from a set of developing and developed countries. This analysis

[6] In their selective review of studies relating resources to earnings, for example, Card and Krueger (1996) tend to find positive relationship. This review mixes some studies that consider family backgrounds with others, including Card and Krueger (1992b), that do not. Betts (1996) provides a further review of these prior estimates.

is made possible by recent international testing and data collection, which provide scores on common examinations across countries.

Such comparative analysis has been largely precluded in the past, although some work does exist. Perhaps the largest and most influential study is Heyneman and Loxley (1983). They analyze data from the Second International Mathematics and Science Study along with other country specific tests. Their primary conclusion is that resource variations appear to be more closely related to student performance in developing countries than in the United States (an issue we return to below).

To put the resource issue into perspective, it is perhaps most useful to begin with aggregate differences across countries. The comparison of cognitive achievement across countries capitalizes on seven voluntary international tests of student achievement in mathematics and science that were conducted over the past three decades. The International Association for the Evaluation of Educational Achievement (IEA) administered five and the International Assessment of Educational Progress (IAEP) administered two. [7] The IEA, since its establishment in 1959, has a long and unique role in developing comparative education research for almost all aspects of primary and secondary education. On the other hand, the IAEP, starting in 1988, builds on the statistical techniques and procedures developed in the United States for the National Assessment of Educational Progress (NAEP), the main national testing instrument in the United States since 1969. While the IAEP is geared to the U.S. curriculum, the IEA has an international focus not associated with the curriculum in any particular country.

The concentration on mathematics and science corresponds to the theoretical emphasis on the importance of research and development activities as the source of growth (e.g., Romer

[7] Details of participating countries, test administration, and sample sizes of the testing prior to the mid1990s can be found in Hanushek and Kim (1995). Barro and Lee (2001) expand international quality measures by including reading and literacy scores along with more recent TIMSS data. We do not include reading and literacy because of concerns about valid testing across languages and doubts about putting these scores into a common one dimensional scale with science and mathematics tests. Reading literacy assessments, for example, are available for 30 countries in 1991 (U.S. Department of Education (1995)).

(1990)). Able students with a good understanding of mathematics and science form a pool of future engineers and scientists. At least for the United States, Bishop (1992) provides separate confirmation of the importance of mathematics in determining individual productivity and income. Additionally, while some test information exists for other subjects, it cannot be compared readily with the mathematics and science scores and therefore is not used here.

An overview of the testing results is best seen from figure 1. This figure shows the country results on each of the math and science tests from the beginning in the early 1960s through the Third International Mathematics and Science Study in 1995. For this, all of the scores in each year are normalized to a world mean of 50 (see Hanushek and Kim (1995); Hanushek and Kimko (2000)). While a different array of countries has participated in the tests, some sense of the overall pattern can be seen from the figure.[8] There is an aggregate tendency for East Asian countries to perform better and for developing countries to score worse. Nonetheless, the performance of individual countries does seem to drift to some extent.

The simplest way to view the pattern is to estimate an "international production function" that pools the data across time and countries. One reason for pursuing this is that the very large differences in resources across countries offers promise that any real resources effects could be detected. Here we present the analysis through 1990, as demonstrated by Hanushek and Kimko (2000).[9] Specifically, there is no pattern to scores and resources, at least after controlling for differences in families over time. Table 1 reproduces the estimated resource effects on achievement for a sample including all country-years of test data that also had complete input data. Of the three separate resource measures—expenditure per pupil, proportion of GDP devoted to public education, and pupil-teacher ratio in primary schools, all three go in the wrong direction.

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[8] An alternative approach to setting the international mean is to benchmark the U.S. tests to the scores on the U.S. National Assessment of Educational Progress. In reality, however, this has little impact since the pattern of the NAEP scores mirrors quite closely the pattern of U.S. rankings on math and science scores in figure 1. See Hanushek and Kimko (2000).

Figure 1.

Performance on International Mathematics and Science Examinations

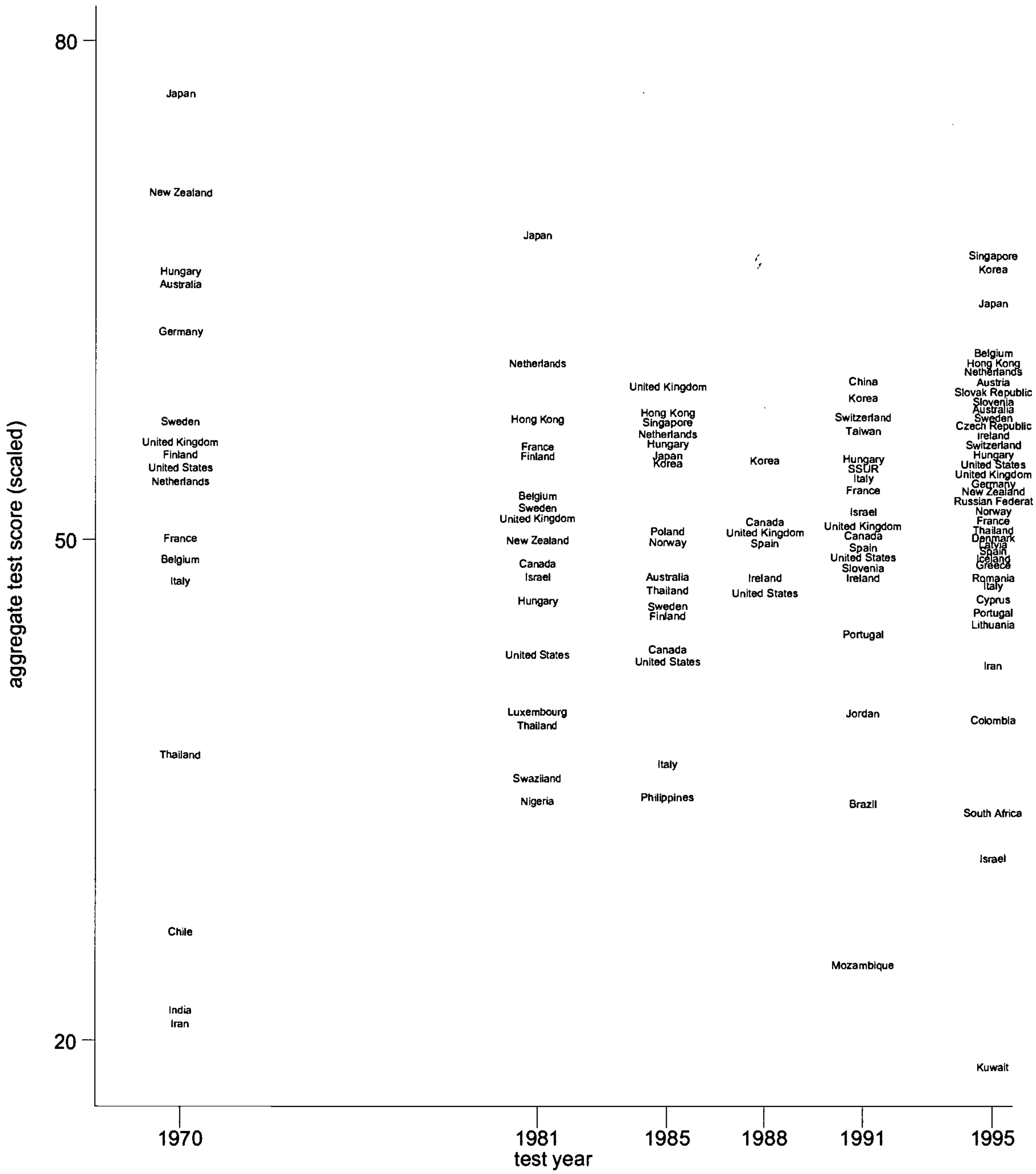

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Table 1. Alternative estimates of the impact of resources on international math and science performance across countries

	Resource coefficients (standard errors)		
Current public expenditure per student	-0.766 (0.21)		
Pupil-teacher ratio in primary schools			0.089 (0.15)
Total expenditure on education/GDP		-189.78 (88.69)	
Number of country-years	69	67	70
R-squared (adjusted)	0.22	0.26	0.25

Source: Hanushek and Kimko (2000).

Note: Each equation includes intercept differences for the specific test, a measure of the average schooling level of adults in the country, and the population growth rate (see Hanushek and Kimko (2000)). Sample includes one observation for each country-year of test data that also has available input measures.

There are good reasons to be cautious about these results, however, since the simplified production function estimates do not measure any organizational or structural differences in the school systems of the various countries. These factors – if important and if correlated with resources – will bias the estimated coefficients.[10] Because these estimates can be biased and because they can mask substantial within-country variation, we go on to consider variations in scores for individual countries.

Cross-country estimation has also been conducted for the TIMSS international testing by Woessman (2000, 2001). He combines the microlevel TIMSS information with data about characteristics of the overall system – centralization, private school options, unionization, and the like – and concludes that organizational features and not resources tend to drive country level performance.

We pursue a different approach. The availability of internationally comparable measures of quality allows us to study the human capital production function at a country level. In this study, we focus on what policies seem associated with increased performance on student tests within each country. Performance will be measured as outcomes on math tests from the Third International Math and Science Survey (TIMSS). This analysis expands previous evidence, which was generally available only at a country level, to provide internationally comparable results.

TIMSS Data

This study relies on data from the Third International Math and Science Study (TIMSS), a testing and data collection program conducted by the International Association for the Evaluation of Educational Achievement (IEA) in 1995.[11] It involved more than 40 countries in three different targeted populations: 9 year olds, 13 year olds, and 17 year olds. Here we focus

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[9] The most important point of this estimation is that it excludes the TIMSS data, the subject of this analysis.
[10] As Hanushek, Rivkin, and Taylor (1996) discuss in the context of U.S. production function estimates, the aggregation of data to the national level will exacerbate any omitted variables bias.

largely on the first and second populations where the country sample is larger and where the data are more complete. TIMSS involved gathering information about student achievement and student backgrounds in the different participating countries, as well as teacher and school characteristics.

The design of TIMSS involved collecting information in each country for 150 schools per age group. At the school level, the standard procedure was to collect two separate individual classrooms corresponding to the two adjacent grades with the largest numbers of students of the target age group. These students were tested, and data about their family backgrounds were collected. Teachers and principals then supplied information about the students, the teachers, and the school.

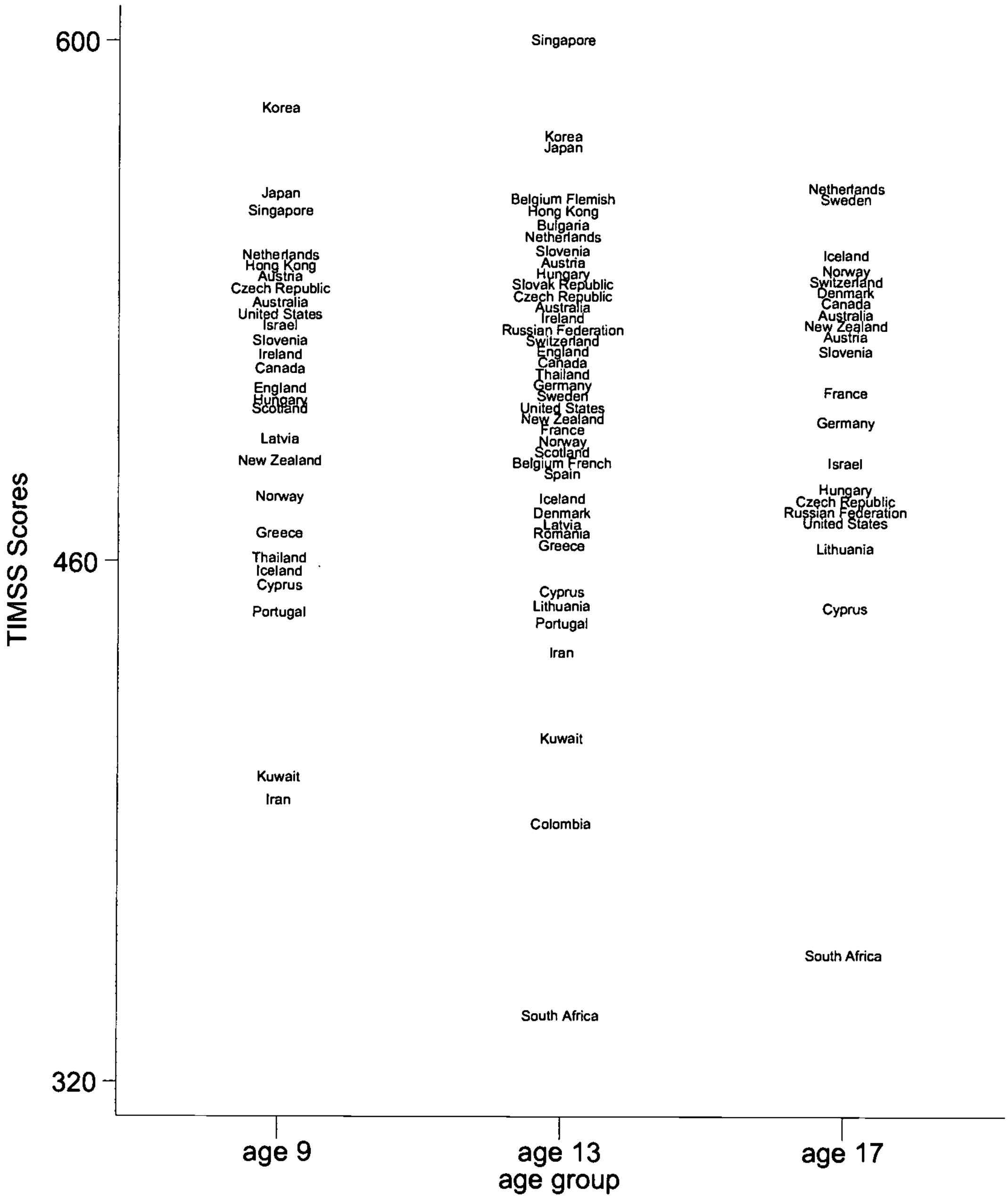
Great care was taken to ensure representative samples of schools and students. There were nonetheless a number of countries that did not comply with all the TIMSS design in terms of sample selection. This selective sampling, which was carefully monitored by the IEA, leads to some doubts about the overall country averages, but it is probably less serious for the analysis done here. For discussion and analysis, see Marlin and Mullis (1996).

The outcomes for average math and science test scores of the countries participating in the TIMSS are found in Figure 2. The math and science test scores were scaled to have a world mean of 50 per test and are designed to be internationally comparable.
East Asian countries dominate the top rankings of the test scores with only Thailand slipping down in the earliest age group. This East Asian advantage is sustained across the different age groups. In general, there are relatively few major movements in the rankings across the different age groups, although the fall of performance by U.S. students as they age is notable.[12] Use students go from 9th out of 26 at age 9 to 22nd out of 40 at age 13 to 18th out of 21 at age 17.

[11] A description of the sampling procedures, testing protocols, and monitoring of performance can be found in Marlin and Mullis (1996). More recently, the TIMSS testing was repeated (TIMSS-R), and this project is described in Gonzales et al. (2000). This study relies on just the first round of TIMSS.

[12] Thailand also goes from the 20th to the 14th position between 9 and 13 year olds.

Figure 2. TIMSS mathematics scores by age cohort



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Education production functions

Most of the public discussion of TIMSS has relied upon national average scores. Here, however, we employ the extensive school data for each country. The large samples and consistent data across countries provide an opportunity to compare international schooling experiences of a wide group of countries.

Our primary goal is assessing the role of school inputs (such as teacher characteristics and class size) and student background characteristics, on student performance. One objective is ascertaining the possibility for using pure resource policies in the schools of different countries to affect labor force quality. The second point of our analysis is consideration in more detail of the dependence of educational outputs on family backgrounds. Household characteristics have been found in the U.S. literature to be one of the most important predictors of educational performance. Does this hold across countries and across different schooling structures?

Our starting point is a standard linear production function defined in terms of achievement levels. We later consider alternative estimation approaches designed to deal with a variety of potential problems.

Consider the simple formulation:

$$O_{ij}^{c} = a_0^c + a_F^c F_{ij}^c + a_S^c S_{ij}^c + \varepsilon_{ij}^c \qquad (2)$$

where i refers to an individual student, j to the classroom, and c to the country for the student. **F** and **S** are multidimensional measures of family and school factors, respectively. The relationship is specified to hold for a specific country and age level and a_F and a_S are country specific parameters relating the various factors to student outcomes. We aggregate the individuals to a classroom level, both for data reasons and for conceptual ones.[13] The nonschool factors (**F**)

[13] The appropriate way to estimate such models has been the subject of considerable past discussion. As a general rule, value-added models which contain information about past student performance levels are superior to the level formulations employed here. The TIMSS data, however, do

common across the estimation include: geographical location and various aggregations of student family background such as the percentage of students whose parents have not completed secondary education or the percentage with various capital goods in the home as a measure of wealth.[14] The school factors (**S**) considered include: total enrollment, teacher characteristics of teacher degree level and teacher experience, grade level, and class size.[15] Teacher education is measured by indicator variables for having a bachelor's degree or having a master's degree and by a separate indicator variable for whether or not the teacher had specialized teacher training. Ordinary least squares are used to estimate the education production functions across classrooms for each country level and for the 9- and 13-year-old samples separately.

The analysis relies on all countries that have sufficient data for estimation of national production functions. There are 18 countries for 9-year-olds and 33 countries for 13-year-olds that have complete data and that are amenable to analysis. Descriptive statistics for the data are displayed in Appendix Tables A1 and A2.

Basic results

The summary of the production function results is presented in table 2. This table aggregates the estimated production parameters for school factors (**S**), which are estimated separately for each country and age group, to see if there are patterns to international performance. The summary indicates the sign and statistical significance (10 percent level) of the

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not support such estimation. The estimates here rely on a similarity of schooling resources over a student's career. See Rivkin, Hanushek, and Kain (2001).

[14] Family background data can be found from two sources – the student reports when they took the tests or the principal responses about various aggregate characteristics. The data from the two sources differ in detail and scope. Our analysis has considered both sources of data, and the overall results are not affected much by the source of data. Nonetheless, the school-based data are available for a smaller set of countries, so we present results just for the analysis based on individual student information about family background.

[15] The age groups can be sampled at different grade levels, and this is controlled for by inclusion of a grade level dummy variable. The estimated models also include dummy variables for rural and urban areas. The class size measure comes from the teacher survey and pertains to the actual size of the specific classroom. At times some of the family or school information is missing, and we include a dummy for these cases with no information in order to not diminish the overall sample size in each country.

Table 2. Distribution of estimated production function parameters across countries and age groups, by sign and statistical significance (10 percent level)

Dependent variable: classroom average TIMSS mathematics score

	Age 9 population					Age 13 population				
	Negative		Positive		Number of countries	Negative		Positive		Number of countries
	Significant	Not significant	Not significant	Significant		Significant	Not significant	Not significant	Significant	
Class Size	**3**	11	2		17	**2**	8	6		33
Teacher with at least a bachelor's degree	0	3	12		15	2	11	12		32
Teacher with special training	0	7	4		12	0	12	11		25
Teacher experience	0	7	6		17	3	9	17		33
School enrollment	0	9	5		17	2	9	15		32

Note: Bold indicates the number of statistically significant results with the expected sign of the effect. Because these estimates rely on actual class size, its expected sign is negative while the estimates for teacher education and experience have an expected positive sign. No clear expectation exists for school enrollment estimated parameters.[16] Entries in bold indicate parameters that are statistically significant and that have the expected sign.[17] Prior analyses, done mostly for the USA, show small or no impact of the common school inputs on educational outcomes. Does that hold for alternative systems with varying organizational structure and incentives?

The results in Table 2 provide a slightly stronger indication of an association between resources and student performance than found in the United States, although the estimates lack the precision needed to have much confidence in any effects. We begin our description with the estimated class size effect. Class size effect seems to have a different pattern at the different ages and grades. For the younger age group, smaller classes have the expected negative sign in 14 out of 17 countries, but the effect is statistically significant (at the 10 percent level) for just three countries. The effect on the 13-year-olds is different. In over half of the countries the impact is positive and statistically significant with only 2 countries showing a negative and statistically significant effect. On the basis of sign of effect, these results are in line with the literature that stresses the impact of smaller classes for younger children, although the imprecision of the estimates introduces considerable uncertainty. We are interested in the causal effects of lowering class sizes, but a possible explanation for the positive results is the use of compensatory policies that place lower achieving students in smaller classes. We return to consider that possibility in the next section.

The level of teacher's education, measured by whether or not the teacher has at least a university degree, provides little consistent impact on student performance. For the younger age group, the estimates tend at least to be positive, but none are statistically significant even at the 10 percent level. For older group, positive and negative results are evenly distributed. Importantly,

[16] Because of the relatively small samples for each country – typically around 300 classrooms for each age group, a loose 10 percent significance level is used throughout in an effort to provide added information about the distribution of results.

[17] The estimated parameters include total enrollment in the school, but there are no clear expectations for the sign of this variable. Note that parameter estimates are obtained for varying numbers of countries, reflecting the fact that some countries did not report complete information. Further, when specific

policy generally dictates more education for teachers of older children. The second measure of teacher preparation is an indicator variable for whether the teacher had specialized teacher training (in addition or in place of a university degree). There is little indication that this specialized training has any impact, although the variations in its definitions across countries make aggregation of these results difficult. However it is organized in the various countries it appears to have little impact on classroom success of teachers.

The teacher experience effects tend to be skewed toward positive achievement, ignoring statistical significance. But only a small number of the estimates are significant even at the 10 percent level for either age group. Total school size tends to be positively related to performance in the older age group, although there is a large variation across countries. Note that this finding is not simply a reflection of schools in isolated or rural areas, because all regressions include an indicator of geographic region.

In addition to the school factors, a variety of family background measures are included. These results (not shown) are quite consistent across countries. Children from favored families (indicated by separate measures of having more than 25 books at home, a calculator, a computer, a study desk, or a dictionary) consistently perform better. Additionally, living with their mother; and, for the older age group, having a mother and father with at least secondary education also contribute positively to achievement. (Parental education measures are unavailable for the younger group). We return below to the persistence of educational effects across generations.

Interestingly, the pattern of results for the school resource factors is virtually unchanged when the family background factors are ignored (not shown). In other words, even if thinking just about proxying overall quality differences of inputs by simple measures of schools, use of the school resource measures is not successful.

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variables were missing for individual schools, a dummy variable indicating missing data was included in the estimation.

Diminishing Returns?

Given the substantial variation in education and degree level of teachers across countries, it is useful to see whether the pattern of student achievement results is related to the overall level of training. In particular, having a university degree might be more important in a country where a minority of teachers complete a degree than in a country where all teachers have degrees. Table 3 displays the training of teachers in each country (ranked by increasing prevalence of a university degree) along with the estimated effects on student performance. The results show no pattern of impacts related prevalence of degree or substitution of teacher training for university degrees.

The preceding estimation also aggregates the results from a wide variety of countries – rich and poor along with those having large and small initial class sizes. This aggregation could potentially mark important and systematic differences across countries. For example, rich countries that devote considerable resources to their schools may find diminishing marginal returns to added resources, while those with relatively few resources devoted to schools may find that added resources have large effects.

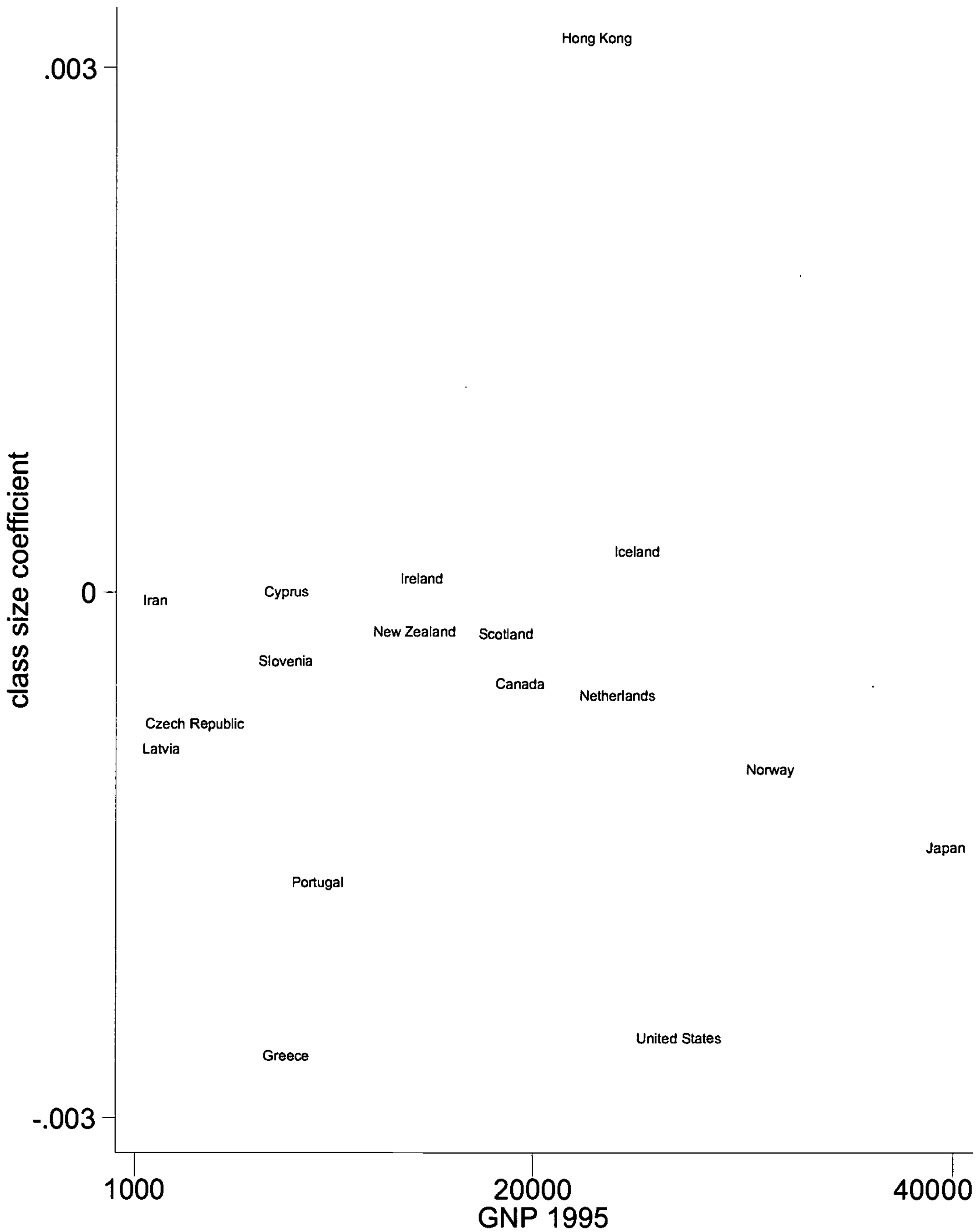
Two different investigations suggest that differential effect of resources across countries by current level of development is not the predominant factor in the array of results. As shown in Figure3, the estimated effects of class size reductions are not systematically larger in poorer countries (as measured by GNP/capita). For 13 year olds (not shown), there is a slight positive relationship between income and the size of the coefficient, but the vast majority shows positive rather than the hypothesized negative effect. Thus, while the data are thin for very poor countries, there is no apparent differential effect by level of national income. Similarly, a similar exercise suggests that there is a small positive relationship between average class size and the class size coefficient when looking across countries for the younger age group.

Table 3. Distribution of Teacher qualifications and Estimated Effect on Outcomes

	Level of qualifications		Estimated effect on student performance			
	University degree	Specialized teacher training	University degree		Specialized teacher training	
			Sign	Signif.[a]	Sign	Signif.[a]
Age 9						
Slovenia	4%	100%	+			
Iran	7%	86%	-		+	*
Netherlands	10%	100%	+			
Norway	10%	95%	+		-	***
Greece	14%	100%	+			
Cyprus	18%	84%	+		-	
Hong Kong	25%	64%	+		-	
New Zealand	29%	99%	+		-	
Scotland	32%	99%	-	***	-	***
Portugal	36%	93%	-		+	
Iceland	53%	94%	+		-	***
Ireland	58%	89%	+		-	
Czech Republic	66%	100%	+			
Latvia	77%	99%	+		-	
Canada	82%	98%	-		+	
United States	100%	96%			+	
Age 13						
Slovenia	5%	92%	-	***	-	***
Netherlands	23%	88%	-	***	-	***
Norway	31%	96%	-	***	-	***
Iceland	41%	90%	-		+	
Romania	43%	92%	+		+	
Switzerland	47%	92%	-		+	
Russian Federation	48%	98%	-		+	
Sweden	51%	68%	+		-	
England	54%	80%	-	***	-	***
France	58%	53%	-		-	
Hong Kong	59%	54%	-	***	-	***
Thailand	61%	93%	-	*	-	
New Zealand	63%	96%	+		-	
Spain	65%	10%	-		+	
Colombia	73%	93%	+		-	
Canada	83%	99%	-	***	-	***
Latvia	83%	94%	+		-	***
Cyprus	83%	79%	+		-	
United States	85%	97%	+		-	
Lithuania	85%	98%	+	*	-	
Scotland	87%	100%	-			
Ireland	92%	95%	-	**	+	**
Portugal	94%	68%	-		+	
Czech Republic	96%	98%	+		-	
Korea	98%	100%	+			
Slovak Republic	98%	99%	-		+	
Greece	99%	13%	+		+	*

Note: a. Statistical significance: * .10 level; ** .05 level; *** .01 level

Figure 3. Estimated Class Size Coefficient by GNP in 1995



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In general, the data provide little support for the thesis that diminishing marginal returns are driving the results.

Selection and compensatory policies

The general lack of support for the importance of class size, including the large number of estimates with the wrong sign, could simply reflect active assignment policies within schools. In particular, if principals tended to place students who have specific problems or are simply doing poorly in smaller classes, these compensatory placement policies could yield results with the incorrect sign. In such case, being in a small class may simply identify prior poor performance as recognized by the principal. Of course, others have identified an opposite relationship –that families with greater wealth buy superior schools with smaller class sizes.

A variety of approaches have previously been used to deal with such problems. The simplest and most straightforward has been estimation of value-added models. In these, achievement at any point in time is related to prior achievement along with the flow of family and school resources. Since the prior achievement captures the incentive for compensatory policies unless assignment is based on things not captured by prior achievement, the impact of class size can be directly estimated. This approach, however, does not lead to stronger results for class size effects in the United States (see Hanushek (1997, 1999)). An alternative approach has been the use of various versions of instrumental variables. These include school level class size in Akerhielm (1995) and specific demographic interactions (Angrist and Lavy (1999); Hoxby (2000)). Case and Deaton (1999) in an alternative approach rely on arbitrary decision making by whites for black schools in South Africa. The evidence from past instrumental strategies is, again, mixed, although there tend to be more estimates of the expected direction.

The requirements for appropriate instruments are typically difficult to meet, and the results tend to hold just for specific circumstances.[18] Nonetheless, while instrumental variables approaches have conceptual appeal, within these international estimates using the TIMSS data it is difficult to find suitable instruments.[19]

To understand the potential for estimates deriving from compensatory placement, we employ two alternative but complementary strategies. First, we consider schools where compensatory placement is not feasible. Specifically, by looking at just rural schools –ones that are much more likely to have only a single classroom in a given grade – we can isolate the impact of class size variation per se. Simply put, if there is not a possibility of allocating students across classrooms, the class size cannot be a reflection of assignment. Second, by including a variable indicating whether the classroom is identified by the principal as being smaller than the average for the grade, we are able to remove the average achievement effect of compensatory setting (if in fact compensatory allocations prevail). We can then observe the impact of class size adjusted for average compensatory policies within schools.

Table 4 (9 year olds) and 5 (13 year olds) display the results of these two investigations of by country. While the overall pattern of estimated class size effects is very similar, these alternative approaches yield a few changes. For the younger students in Table 4, negative impacts of larger classes become statistically significant in the rural schools of Canada and Slovenia and, in Hong Kong, the estimate goes from positive significant to negative significant. On the other hand, Cyprus becomes positive and significant for rural schools. The precision of estimates also falls in several countries. For the older students in Table 5, some positive effects turn into

[18] An appropriate instrument must be correlated with the variable of interest (here, class size) but uncorrelated with the selection rule of schools in terms of unmeasured achievement. Angrist and Lavy (1999), for example, make use of a peculiarity in Israeli schooling policy ("Maimondides' rule") in order to look exogenous variations in class size. Hoxby (2000) capitalizes the "lumpiness" of classrooms to observe variation in class size induced to demographic differences.

[19] Woessman and West (2002) use an instrumental approach in an alternative recent analysis of the TIMSS data. They rely on grade average class size instead of the number of students in the specific tested classroom along with removing a school fixed effect to deal with school selection.

Table 4. Sign and statistical significance of alternative estimates of class effects allowing for compensatory placement, age 9 cohort

	Full sample		Rural sample		Within school small classes[a]			
	Sign of class size estimate	Statistical Significance[b]	Sign of class size estimate	Statistical Significance[b]	Sign of small class indicator	Statistical Significance[b]	Sign of class size estimate	Statistical Significance[b]
Canada	-		-	**	-	**	-	*
Cyprus	-		+	*	+		+	
Czech Republic	-		-		-	*	-	
Greece	-	**	-		-		-	**
Hong Kong	+	***	-	***	-	**	+	***
Iceland	+		-		-		+	
Iran	-		+		-	***	-	
Ireland	+		+		-		-	
Japan	-	***	-		+		-	*
Latvia	-		-		-		-	
Netherlands	-		-		+		-	*
New Zealand	-		+		+		+	
Norway	-		-		+		-	
Portugal	-		+		-		-	
Scotland	-		-		+		+	
United States	-	***	-	*	-		-	***
Slovenia	-		-	**	-		-	

Notes:
a. Estimates based on full sample with inclusion of an indicator variable for whether the classroom has fewer students than the average for the grade.
b. Statistical significance:
* .10 level
** .05 level
*** .01 level

Table 5. Sign and statistical significance of alternative estimates of class effects allowing for compensatory placement, age 13 cohort

	Full sample		Rural sample		Within school small classes[a]			
	Sign of class size estimate	Statistical Significance[b]	Sign of class size estimate	Statistical Significance[b]	Sign of small class indicator	Statistical Significance[b]	Sign of class size estimate	Statistical Significance[b]
Austria	+		+		+		+	*
Belgium (Fl)	+	***	+		+		+	***
Belgium (Fr)	+	***	+	*	-		+	***
Canada	+	**	+		+		+	**
Colombia	-		+		-	*	-	
Cyprus	+		+		-		+	
Czech Republic	+	***	+		-	**	+	
Slovak Republic	-		-		-	**	-	
Denmark	+		+		+		+	
France	+	***	+	**	+		+	**
Germany	+	**	+		+		+	***
Greece	-	*	-		-		-	
Hong Kong	+	***	n.a.		-		+	***
Iceland	+	**	+		-		+	
Ireland	+	***	+	***	-	**	+	***
Japan	+	***	-		-		+	***
Korea	-	*	-		-		-	*
Latvia	-		-	**	-		-	
Lithuania	+	***	+		+		+	***
Netherlands	+	***	+	***	+		+	***
New Zealand	+	***	+		-	**	+	
Norway	-		+		-		-	
Portugal	+	***	n.a.		+		+	***
Romania	+		-		-		+	
Russian Fed.	+		-		-		-	
Spain	-		+		+		-	
Sweden	+	***	+	***	+		+	***
Switzerland	-		-	**	+		+	
Thailand	+		+		+		+	
England	+	***	+	***	n.a.		n.a.	
Scotland	+	***	n.a.		-		+	***
United States	-		-		-		-	*
Slovenia	-		+		+		-	

Notes: n.a. Country data are unavailable to perform estimation.
a. Estimates based on full sample with inclusion of an indicator variable for whether the classroom has fewer students than the average for the grade.
b. Statistical significance: * .10 level; ** .05 level; *** .01 level

negative, but not significant (Japan, Romania and Russian Federation). In general the positive results become less significant in the smaller samples of rural schools.

The identification of class sizes that are below the grade average provides an indication of the tendency toward compensatory policies in each country. Across all countries at the different grade levels, the estimated effects are almost evenly split between compensatory and "elitist" placement, but the statistically significant differences favor compensatory placement. Four of 17 countries for the younger age group and five of 32 countries for the older age group show lower achievement in the classrooms with smaller than the grade average for the school class sizes (holding constant the class size). Importantly, identification of such within school placements does little to change the sign or significance of the estimated class size effects.

These alternative approaches to assessing the importance of compensatory class size policies do not indicate that the overall results are heavily influenced by selection effects. Thus, other explanations must be found for the patterns of results, particularly the predominantly perverse effects found for the samples of 13-year-olds.

Families and Schools

One issue of some significance is how the education systems of various countries impact on the distribution of outcomes. The results here, mirroring those in most other studies, show that family background exerts a very strong effect on student performance. Students from disadvantaged families and from families where the parents themselves have less education tend to systematically perform worse on the TIMSS tests than do students who do not have those deficits.

Heyneman and Loxley (1983) focused attention on the relative importance of family background and school factors. In this work, which parallels that of Coleman et al. (1966), they compare the amount of variance explained by family background with that explained by school factors. Their analysis suggests that measured school resources explain a considerably higher proportion of the variance in poor countries, leading them to conclude that school resources are more important in developing countries.

In table 6, we reproduce their analysis for the consistent database from TIMSS. Heyneman and Loxley (1983) approach the problem by looking at the marginal addition to explained variance that is provided by school factors. In other words, employing the methodology of Coleman et al. (1966), they first remove all of the variance in test scores that can be attributed to family backgrounds. They then add school factors and look at the addition to explained variance (column 1). In their analysis, the latter is a substantial percentage of the total explained variance (column 3). When we do a similar analysis as shown in the next to last column (lower bound of variance explained by school factors), we do not reproduce their results. First, the proportion explained by the addition of school factors is relatively modest, particularly for the sample of 9 year olds. Second, there is no clear relationship with income of the countries. The countries have been ordered from poorest to richest, but there is not a simple monotonic pattern in the relative importance of school factors.

Substantial criticism was leveled at the original Coleman Report for this methodology (e.g., Hanushek and Kain (1972)). Specifically, this methodology attributes any "common explained variance" to family factors. In other words, when family and school factors are positively correlated, the first regressions with only family variables include the effect of family background plus a portion of the schools effect that is proxied by the collection in family factors. The importance of such correlation is shown by column 2 and by the final column (upper bound of variance explained by school factors). In column 2, family factors are ignored, effectively reversing the calculation by attributing all of the common explained variance to school factors. When this is done, school factors appear to explain a majority of the total explained variance in most countries.

Importantly, regardless of how the calculations are done, there is no clear pattern by wealth of the country. In other words, it does not appear that school resources are differentially important in poorer countries.

A more fundamental problem with this approach is the reliance on comparisons of explained variance to derive conclusions about the importance of resources. The variance explained by a set of regressors combines information about the impact of each factor (i.e., its coefficient), the correlation with other inputs, the observed variance of each, and the observed variance of the test score outcomes. The latter three factors are a function of the particular sample and institutional structure. For example, if all of the schools in a country had precisely the same class size, class size could not explain any of the observed variance in test scores – regardless of how important class size might be for student learning. Similarly, if student backgrounds showed relatively little variation within a country, families would offer little explanation for test score variations even though they were very important.

A more subtle issue also arises, since concentration on explained variance neglects consideration of how school resources are estimated to affect performance. For example, the previous summaries of the estimated parameters (table 2) showed that 17 out of the 33 estimates for class size effects for the age 13 population were positive. A number of these are statistically significant, and, while they will contribute to the test score explanation, this evidence would hardly be appropriate for arguing about the importance of school resources in developing countries.[20]

A slightly different issue is whether the schooling system tends to reduce achievement gaps found at entry to schooling. Specifically, if we take the distribution of achievement at entry

[20] An alternative approach to assessing the role of measured school resources is to compare their impact to some objective standard such as the academic deficit of disadvantaged students. Our estimates allow us to calculate the percentage change in achievement that can be expected from a reduction in class size. These can be compared to average difference in performance for disadvantaged students (measured according to our SES measures). The estimates uniformly show unrealistically large changes in resources to eliminate the gaps. For example, the best cases for class size reduction imply a necessity to reduce class size by ten

Table 6. Additional Explanatory Power of School Inputs

(Countries ordered by increasing GDP/capita)

	Variance explained by school factors (ΔR^2)		Total	Importance of school factors	
	Entered after family	Entered before family	explained variance (R^2)	Lower bound	Upper bound
	(1)	(2)	(3)	(1)/(3)	(2)/(3)
Age 9					
Iran	0.01	0.47	0.68	1%	69%
Latvia	0.03	0.32	0.55	5%	59%
Czech Republic	0.03	0.39	0.49	6%	79%
Slovenia	0.02	0.50	0.64	2%	78%
Cyprus	0.07	0.58	0.61	11%	95%
Greece	0.02	0.39	0.57	3%	68%
Portugal	0.03	0.24	0.49	7%	48%
New Zealand	0.01	0.22	0.62	2%	35%
Ireland	0.02	0.41	0.67	3%	61%
Scotland	0.01	0.36	0.59	1%	62%
Canada	0.02	0.36	0.54	4%	65%
Hong Kong	0.04	0.51	0.66	6%	77%
Netherlands	0.04	0.60	0.68	5%	88%
Iceland	0.01	0.45	0.56	1%	81%
United States	0.03	0.30	0.66	5%	45%
Norway	0.01	0.56	0.68	1%	82%
Japan	0.02	0.63	0.67	3%	94%
Age 13					
Romania	0.07	0.19	0.39	17%	49%
Lithuania	0.05	0.38	0.54	9%	71%
Colombia	0.05	0.20	0.62	8%	32%
Russian Federation	0.04	0.17	0.40	9%	42%
Latvia	0.03	0.21	0.34	8%	61%
Thailand	0.11	0.44	0.56	19%	79%
Slovak Republic	0.04	0.29	0.46	9%	62%
Czech Republic	0.02	0.24	0.58	4%	42%
Slovenia	0.01	0.36	0.57	2%	63%
Cyprus	0.02	0.33	0.69	3%	47%
Greece	0.04	0.37	0.67	6%	56%
Korea	0.03	0.42	0.63	5%	68%
Portugal	0.05	0.36	0.58	8%	62%
Spain	0.02	0.34	0.61	3%	56%
New Zealand	0.03	0.21	0.58	5%	36%
Ireland	0.11	0.32	0.55	21%	57%
England	0.19	0.22	0.36	54%	61%
Scotland	0.08	0.26	0.57	14%	47%
Canada	0.05	0.19	0.32	15%	59%
Hong Kong	0.15	0.30	0.66	22%	45%

Sweden	0.14	0.29	0.43	32%	67%
Netherlands	0.11	0.45	0.70	16%	64%
Belgium (Fl)	0.05	0.21	0.52	9%	40%
Belgium (Fr)	0.07	0.37	0.72	10%	52%
Iceland	0.05	0.22	0.36	14%	62%
France	0.05	0.36	0.54	9%	66%
Austria	0.04	0.21	0.33	11%	64%
United States	0.02	0.11	0.45	4%	23%
Germany	0.02	0.22	0.75	3%	30%
Denmark	0.09	0.44	0.51	18%	87%
Norway	0.05	0.42	0.57	9%	74%
Japan	0.10	0.36	0.41	25%	88%
Switzerland	0.03	0.19	0.45	6%	42%

to school to reflect just nonschool factors, does schooling provide a set of independent inputs that become increasingly important and reduce the impact of families? The presence of two adjacent cohorts at different points in the schooling process allows an evaluation of the impact of schools on the link between family characteristics and educational outcomes. To look at the effect over time of families, we normalize the test scores for each age group to have a mean of 0 and standard deviation of 1. We then pool the age 9 and age 13 cohorts and test whether the family background effects are the same across ages.[21] The results change slightly depending on which family background measure is used, the effect for the presence of 25 or more books at home is illustrative. For seven of the twelve countries (those with sufficient data for the estimation), the differential effects of family inputs indicate a significant lessening influence of families (Canada, Czech Republic, Hong Kong, Iceland, Ireland, Latvia, New Zealand, and Norway). The only country that significantly goes in the opposite direction is Portugal. These results generally hold up for other measures of family wealth or home environment.

Conclusions

Strong evidence indicates that quality of human capital is very important for individual success and for nations as a whole. Until recently, however, it has been difficult to look at quality across nations in a consistent manner. Most of the evidence about the determination of quality has been restricted to the United States. The availability of a common performance measurement for students in different countries permits an investigation of the operations of school systems in up to 37 countries.

This analysis considers policies that might be used to promote higher quality schools within countries. The particular emphasis is the power of resource policies such as improving

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or more standard deviations in order to close the achievement gap between poor and the rest of the countries.

teacher education or reducing class sizes. These policies have proven ineffective in the United States, but this situation does not necessarily hold elsewhere. If there are diminishing marginal impacts of school resources, the United States could simply be working on a "flat" portion of the production function, while other countries might not be.

Across the sampled TIMSS countries, the overall strength of resources in obtaining better student performance appears rather limited, but it is more positive than in the corresponding analyses of U.S. achievement. Certain countries also do stand out as having significant effects, and these should be investigated in more detail. Nonetheless, the results defy many generalizations. It simply does not appear to be the case that outcomes related to school resource differences are more positive in the poorer countries or in the countries that begin with lower levels of resources.

A common concern from this estimation is that the estimated effects might simply be an artifact of direct policy actions in different nations. The strongest potential case involves class sizes. If schools systematically use reduced class size in a compensatory manner to make up for past learning difficulties of individual students, a positive relationship between class size and student performance could simply reflect the selection of students and not the true causal impact of reduced class size. To investigate this possibility, two separate approaches are used. First, because rural schools tend to be small and tend to have a single class in each grade, the ability to allocate students in a compensatory manner is sharply limited. Estimation of models just for rural schools provides no more general support for class size policies than the prior estimation across all schools. Second, the principal of schools identified if the particular sampled classroom had a class size below average for the grade in the school. We separate out the average achievement differences for within-school small classrooms and then investigate the impact of class size

[21] In a separate analysis, we also calculate coefficients of variation for each country and age group. While overall these show no narrowing of the distribution, these measures are subject to the underlying variation of test measurement and thus are difficult to interpret.

differences. While a number of countries appear to place lower achieving students in small classrooms, allowing for this does not change the pattern of class size effects.

Looking beyond simple resource policies appears necessary. Variations in performance across countries do suggest that a variety of organizational and incentive issues are likely to be more important than concentration on just resources to schools, a result supported by Woessman (2000, 2001).

Finally, we investigate whether the schooling systems in various countries appear to ameliorate the impact of poorer family backgrounds. It has been conventionally held, particularly following Heyneman and Loxley (1983), that schools and school resources are more important than families in developing countries. Our analysis, using alternative methods, does not support the notion that school resource impacts vary systematically with country income or development. Further, when we investigate the impact of family backgrounds comparing younger with older students, we find mixed evidence that the impact of families tends to decline with age. This analysis is, nonetheless, relatively imprecise and should not be taken as conclusive.

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Appendix Table A1. Descriptive statistics for Age 9 cohort

	Class size(students)	Not working	Lives with mother	More than 25 books at home	House with calculator	House with computer	House with study desk	House with dictionary	Teacher experience (in years)
Canada	22.8	14%	91%	78%	81%	51%	73%	80%	18.9
Cyprus	26.4	16%	87%	52%	72%	32%	82%	77%	17.6
Czech Republic	19.1	7%	97%	83%	93%	31%	77%	76%	22.6
Greece	20.0	22%	95%	49%	56%	21%	82%	85%	16.8
Hong Kong	36.2	20%	94%	47%	91%	35%	74%	94%	14.8
Iceland	14.4	23%	87%	82%	75%	73%	85%	70%	14.5
Iran	31.9	8%	74%	18%	37%	8%	23%	27%	16.2
Ireland	21.8	12%	96%	67%	82%	72%	69%	90%	20.6
Japan	31.4	15%							16.1
Latvia	18.7	8%	93%	76%	74%	21%	92%	78%	20.5
Netherlands	21.2	21%	89%	70%	81%	69%	84%	76%	17.4
New Zealand	28.9	19%	88%	79%	86%	52%	73%	89%	15.5
Norway	17.4	14%	95%	81%	68%	51%	86%	67%	18.9
Portugal	19.3	27%	94%	37%	76%	31%	60%	83%	21.8
Thailand	19.4	13%	93%	23%	43%	4%	41%	32%	20.0
Scotland	23.3	23%	91%	71%	84%	83%	71%	86%	15.1
United States	23.5	15%	93%	73%	91%	51%	81%	89%	16.4
Slovenia	21.9	8%	97%	70%	73%	44%	85%	79%	19.2

Note: blank entries indicate no data available.

Appendix Table A2. Descriptive statistics for Age 13 cohort

	Class size(students)	Mother with at least secondary education	Father with at least secondary education	Not working	Lives with mother	More than 25 books at home	House with calculator	House with computer	House with study desk	House with dictionary	Teacher experience (in years)
Austria	4.7	57%	63%	17%	95%	72%	98%	58%	90%	97%	32.4
Belgium (Fl)	17.2	37%	41%	11%	96%	75%	97%	67%	96%	99%	23.5
Belgium (Fr)	15.7	44%	46%	21%	94%	83%	97%	59%	95%	96%	35.0
Canada	17.8	60%	55%	8%	92%	83%	96%	59%	87%	95%	23.3
Colombia	30.5	30%	31%	6%	85%	41%	87%	11%	83%	95%	22.6
Cyprus	23.2	22%	24%	18%	93%	73%	93%	36%	94%	95%	27.2
Czech Republic	17.9	53%	47%	3%	97%	94%	98%	35%	89%	94%	22.9
Slovak Republic	20.6	60%	54%	4%	96%	86%	98%	32%	86%	95%	22.3
Denmark	18.0	43%	43%	11%	92%	83%	95%	72%	94%	80%	21.7
France	21.6	29%	27%	20%	92%	73%	95%	47%	92%	95%	29.5
Germany	15.9	24%	28%	15%	94%	74%	98%	69%	92%	96%	43.5
Greece	24.8	37%	40%	24%	96%	71%	83%	28%	92%	96%	13.5
Hong Kong	31.9	26%	30%	17%	93%	50%	97%	37%	78%	97%	13.5
Iceland	11.7	42%	51%	11%	94%	92%	98%	71%	95%	91%	31.1
Ireland	19.2	49%	44%	10%	96%	75%	95%	77%	84%	97%	21.8
Japan	35.5			18%							15.1
Korea	52.9	53%	66%	38%	94%	80%	91%	38%	95%	98%	13.9
Latvia	14.3	48%	41%	2%	94%	92%	90%	13%	96%	91%	28.0
Lithuania	15.4	49%	44%	6%	96%	77%	85%	44%	93%	85%	32.2
Netherlands	19.7	50%	54%	13%	95%	74%	96%	80%	95%	96%	20.2
New Zealand	20.8	51%	47%	9%	92%	87%	96%	59%	87%	97%	17.4
Norway	14.6	48%	50%	4%	95%	91%	96%	63%	97%	94%	22.9
Portugal	22.2	15%	16%	20%	94%	61%	98%	39%	82%	96%	13.2
Romania	18.0	39%	40%	11%	82%	49%	58%	17%	68%	55%	26.2
Russian Federation	11.8	78%	70%	4%	96%	83%	89%	35%	94%	85%	59.7
Spain	21.9	22%	27%	16%	96%	76%	97%	40%	92%	99%	25.8
Sweden	13.6	45%	43%	8%	94%	87%	98%	58%	98%	92%	26.2
Switzerland	11.9	49%	56%	15%	96%	77%	98%	61%	95%	97%	24.5
Thailand	23.8	9%	15%	2%	92%	44%	59%	3%	57%	59%	46.0
England	21.8			15%	94%	79%	97%	88%	88%	95%	25.5
Scotland	20.3	32%	30%	17%	90%	67%	91%	84%	78%	90%	23.9
United States	18.3	75%	70%	10%	90%	75%	96%	54%	87%	95%	27.0
Slovenia	21.3	60%	63%	4%	97%	80%	97%	46%	93%	92%	23.4

Note: blank entries indicate no data available.

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