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Searching for the Golden Model of Education: Cross-National Analysis of Math Achievement

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Abstract

We utilized four waves of TIMSS data in addition to the information we have collected on countries' educational systems to examine whether different degrees of standardization, differentiation, proportion of students in private schools and governmental spending on education influence students' math achievement, its variation and socioeconomic status (SES) gaps in math achievement. *Findings:* A higher level of standardization of educational systems was associated with higher average math achievement. Greater expenditure on education (as % of total government expenditure) was associated with a lower level of dispersion of math achievement and smaller SES gaps in math achievement. Wealthier countries exhibited higher average math achievement and a narrower variation. Higher income inequality (measured by Gini index) was associated with a lower average math achievement and larger SES gaps. Further, we found that higher level of standardization alleviates the negative effects of differentiation in the systems with more rigid tracking.

Keywords

standardization; differentiation; governmental spending on education; math achievement; socioeconomic gaps in achievement

Educational systems have been universally perceived as the main producers of society's human capital. In today's inter-connected world, the labor market clearly is an international endeavor. Educational systems are in competition against each other to produce competent, knowledgeable and skillful workforce for tomorrow. Within educational systems, competition often exists among the actors--students and their families-- for the best possible education they can access in order to maximize their academic achievement. Historically, in science, technology, engineering, and mathematics (STEM) fields, US scientists have competed with the Soviet scientists, especially during the Cold War. After the collapse of the socialist camp and the end of the Cold War, the weight of the competition has shifted towards East Asia, in particularly to Japanese and Korean markets. Today all of these countries participate in an increasingly international educational market, which makes it only more important to conduct systematic comparative studies of educational systems and their outcomes.

Existing international comparative studies of education have typically employed *one wave* of international data, such as the Trends in International Mathematics and Science Study (TIMSS) or the Programme for International Student Assessment (PISA), and examined specific trends and associations across most, if not all, participating countries (Alegre and Ferrer 2010; Barone 2006; Bol et al. 2014; Brunello and Checchi 2007; Dronkers and Robert 2008; Marks 2006; Park 2008; Schlicht et al. 2010, to name a few). Alternatively, other studies have focused on *one specific country*, addressing peculiarities of that country's political, social and educational processes (see for example the edited volume by Shavit & Blossfeld [1993]; or a collection of articles by Willms [2006]). In the latter case, the main dependent variable typically was educational *attainment* (e.g., Gerber 2000; Gerber and Hout 1995, 2004; Mateju 1993; Szelenyi and Aschaffenburg 1993). Educational trajectories are a cumulative process; several studies pointed to the crucial importance of both skills and attitudes formation in early years to later outcomes. Thus, it seems important to examine trends shaping students' academic *achievement*, that has been proven to significantly affect future educational attainment (Sewell and Hauser 1976; Sewell et al. 1970; Trusty 2002; Tyson et al. 2007), which, in turn, has been linked to a variety of outcomes, including individuals' occupational attainment, health and wellbeing. Given the profound effects educational outcomes have on one's life chances, the factors that produce it are worth an investigation and the comparative perspective deepens our understanding of the larger contexts in which educational outcomes are shaped.

We build upon this existing research and improve it a number of ways. In addition to utilizing the four waves of TIMSS data, we compiled data from various sources about country-level institutional characteristics of the educational systems such as degree of standardization, differentiation, privatization and governmental spending on education, to test whether these characteristics moderate the effects of family socioeconomic status (SES) on academic achievement.

Specifically, we examined two main research questions in this study:

1. To what extent are institutional characteristics of countries' educational systems, such as the degree of differentiation, standardization, privatization, and governmental spending on education related to countries' mean math achievement and variation in math achievement?
2. Do these institutional characteristics moderate the effects of family SES on math achievement?

Current Knowledge

Starting with the classical work by Blau and Duncan (1967) and Sewell and Hauser (1976), which were among the first to use modern statistical methods to link parental social class to children's educational and occupational attainment, study after study has determined that within each country higher family socioeconomic standing is related to better academic outcomes (Bodovski 2010; Bodovski et al. 2013; Levels et al. 2008; Marks 2005, 2006). While a prolific stream of research has focused on an understanding of micro level mechanisms that explain inter-generational transmission of social class advantage (Bernstein

1975; Bourdieu 1986; Bowles and Gintis 1976; Farkas 2003; Lareau 2000, 2003 to name a few), other scholars of education have been concerned with the role the macro characteristics of countries' educational systems play in moderating the family effects on educational outcomes.

Kerckhoff (2001) made an important contribution to this investigation by formulating four aspects of educational systems (stratification, standardization, vocational specificity, and student choice) and reviewed the literature on the student trajectories of transitioning through school and from school to work in France, Germany, Great Britain and the United States. He concluded that there is a need for further specification of a broad framework that will take into account informal social processes as well as system structure and will help our understanding of "the different societies' methods of sorting young people into the stratified labor force" (Kerckhoff 2001:15). A comprehensive review of a number of studies using Progress in International Reading Literacy Study (PIRLS), PISA and TIMSS data by Van de Werfhorst and Mijs (2010) concluded that highly differentiated systems exacerbate educational inequality, whereas higher standardization decreases inequality. Further, they argued that educational differentiation leads to a lower mean achievement in a country.

In this study we examined to what extent the features of educational policy, such as the degree of differentiation, standardization, privatization, and governmental spending on education moderate the effects of family background on academic achievement. We discuss each of these aspects of educational systems below.

Differentiation

The current literature debates whether less differentiation means higher equality and higher overall achievement. Research on tracking and ability grouping shows that students from privileged background are more likely to be enrolled in higher status academic tracks, whereas low socio-economic status and minority students are concentrated in vocational tracks (Buchmann and Park 2009; Combet, 2015). Further, track placement strongly affects student achievement: students in higher tracks show faster achievement growth, whereas the achievement gains of lower track students are slower (Alexander et al. 1978; Dauber et al. 1996; Gamoran 1987, 1992, 1996; Gamoran and Mare 1989; Hallinan 2003; Kerckhoff 1986). Several studies have argued that tracking and ability grouping exacerbate educational inequality (Horn 2009; Kerckhoff 1995; Oakes 2005), while other studies showed that it is not tracking itself but an opportunity (or the lack of thereof) to change tracks that affects inequality (Hallinan 1994; Stadelmann-Steffen 2012).

Educational differentiation in the form of tracking or ability grouping is not just a concern for the national level of policy making but has been a focus of comparative and international research as well. Societies differ greatly in the degree and timing of differentiation. Countries such as Austria, Germany and Switzerland are known for their rigid and early tracking; whereas Finland, Sweden, Australia and the United States have comprehensive educational systems (although in the U.S. there is enough evidence that de facto students are not exposed to the same curriculum or even type of courses in the secondary school). Studies showed that timing of differentiation, e.g., the age at which tracking takes place, has been

found influential, with early tracking systems exhibiting stronger social inequality (Brunello and Checchi 2007; Hanushek and Wößmann 2005; Marks 2006).

Using PISA 2006, Schlicht and colleagues (2010) compared the effects of educational policy on inequality in academic achievement in 25 EU member countries. Their main finding was that these effects vary greatly by country. For instance, tracking (measured as a dichotomous variable) was more strongly related to inequality in achievement in post-socialist countries compared to Western European countries. Furthermore, the negative effect of tracking on mean country achievement is also stronger in Eastern Europe than in Western European states (Jakubowski, 2010). It is important to note that low inequality does not necessarily mean high efficiency. In a study of seven post-socialist countries of Central and Eastern Europe, Ammermuller et al. (2005) found that the four high performing countries (Hungary, Czech Republic, Slovakia and Slovenia) have tracked systems with higher levels of inequality, whereas low performing countries (Lithuania, Latvia and Romania) had comprehensive systems.

Despite the argument that tracking allows differentiated instruction that will target all group of students, and thereby maximizing their learning, Park (2005) found that on average countries with higher levels of differentiation do not exhibit higher levels of educational performance. At the same time, high differentiation was associated with greater socioeconomic differences between schools while decreasing SES effects within schools. Similar findings were reported by Bol et al. (2014) who explained that in highly differentiated systems SES related selection has already happened in student assignment to a particular secondary school and as such will not be present in relation to achievement in the secondary school.

These findings call for more nuanced and systematic measures of differentiation within countries' educational systems as well as for analyses that will take into account other characteristics of countries in general (level of economic development and inequality) and those of their educational systems in particular. In our study, we created such data by collecting information on countries' educational systems from various sources, as well as used these measures as moderators for the family effects on educational outcomes over time.

Standardization

Another important aspect of educational systems is the degree of standardization that refers to the degree to which the central government has control over curriculum, teachers' training and preparation, and whether or not the country has a central national examination. In highly standardized educational systems (e.g., France, South Korea), students are taught common curricula and have access to a relatively similar quality of teachers and schools regardless of their socioeconomic background (Byun and Kim 2010). In addition, in more standardized educational systems, low SES families tend to have fewer difficulties in engaging with schools and teachers because standardized curriculum and instruction help parents have a clear idea of what students are expected to learn. Further, standardized tests can help even low SES families easily monitor their children's educational progress (Park 2008). By contrast, in less standardized systems (e.g., US), low SES students are more likely than high SES students to enroll in schools with poor resources and to be taught by ill-prepared

teachers (Akiba, LeTendre, and Scribner 2007). In addition, low SES families tend to have more difficulties in navigating educational systems (e.g., track placement, school choice, extra-curricular activities) because of a lack of transparency in schooling (Park 2008). As such, there will be less educational inequality in more standardized educational systems than in less standardized educational systems.

Bishop (1997) discussed the role curriculum-based external exit examinations (CBEEE) play in inequality of student achievement in the comparative perspective. Using data from TIMSS 1995 and from the International Assessment of Educational Progress 1991, he found that students in countries with CBEEE's outperform students in countries without standard exit exams on math and science. In their analysis of 27 OECD countries, Schutz et al (2007) find that exit exams are associated with better student mathematics performance, and that the relationship is stronger for students from middle and higher socioeconomic classes than from lower socioeconomic classes. Fuchs and Wößmann (2008) show that student performance in science is higher as well, albeit marginally, in countries where there are external exit exams. In a within-country analysis, Carnoy and Loeb (2002) assess the strength of accountability in 50 US states – they include whether states have a high school competency exam necessary for graduation into the measure - and find that increased accountability is associated with increased student outcomes on National Assessment of Educational Progress (NAEP) math test. Furthermore, CBEEs are argued not only to increase student achievement due to supervision effects, but that they also help decrease the deleterious effect of peer pressure on student learning and increase student rewards for taking school work seriously (Bishop and Wößmann 2004).

By contrast, conducting an analysis of PISA 2000 data for 32 countries, Park (2005) did not find significant effect of countries' level of standardization on average achievement. He argued that more standardized systems do not necessarily increase students' performance in absolute levels, but high standardization was associated with less socioeconomic inequality in student achievement within schools.

Fuchs and Wößmann (2007) used PISA 2000 data to conduct their analysis of various institutional characteristics of the countries and how they affect students' achievement. They concluded that exit exams were positively associated with countries' math achievement; they were only marginally related to science achievement and did not have significant association with reading achievement. Interestingly, regular standardized testing of the students was associated with higher performance across subjects. The existing literature presents conflicting evidence regarding the effectiveness of centralized curricula (Scheerens 2013). Some scholars argue that in geographically dispersed countries with high diversity, such as the U.S., a standardized curriculum cannot possibly address the diverse needs of students and cannot be delivered as intended (Clune 1993).

At the same time, there are benefits to having a more centralized curriculum. For example, having mandated curricular guidelines provides a sufficiently balanced curriculum to every student irrespective of the school they attend (English and Steffy 2001); it also ensures that no inappropriate repetition of the taught material happens as children progress through school (Vulliamy and Webb 1995). In several countries, most notably in Singapore, sharp

increases in math and science achievement on international assessments have occurred alongside within-country changes towards more centralized curriculum, such as producing guidelines regarding how subjects should be taught (Walberg et al. 2000).

It is important to examine the effects of different aspects of educational systems simultaneously because previous studies have pointed out the interaction effects among different institutional features. Centralization of the educational system has been argued to influence the effects of differentiation mentioned above. For example, Bol et al. (2014) find that the positive relationship between tracking and inequality is attenuated by the presence of central exit examinations. The authors argue that central exit examinations serve as a controlling mechanism that encourages administrators to properly allocate students into tracks and to provide quality instruction to both those in higher and lower tracks. Other scholars argue that it is not the central exit examinations that moderate the relationship between tracking and inequality but rather whether students are selected into tracks based on a standardized exam or teacher evaluation or recommendation (Combet 2015). In fact, Combet (2015) argues that high-SES students benefit from having standardized exams that serve as gatekeepers to more prestigious tracks as they are in a better position to prepare well for those tests than students from lower-SES families.

A comparative study on the United States and Israel (Ayalon and Gamoran 2000) argued that inequality in educational achievement by social class is more strongly affected by tracking in an unstandardized educational system without central examinations (the United States) than in a standardized system with high-stakes central exams (Israel). A recent study by Bol et al. (2014) confirmed this finding in a larger scope of countries. Using PISA 2006 data on 36 countries, the authors found that parental SES influences student achievement more in educational systems without central exams. Where central exams are present, the relationship between SES and tracking was attenuated. Our paper sheds light on the role different aspects of standardization play in shaping academic achievement and educational inequality by utilizing detailed information for all studied countries in terms of the presence of prescribed textbooks, regulated curriculum and presence of central exams.

Privatization

Another aspect of the education system is the proportion of students in private schools in a country. An early study of twelve advanced industrial countries and 38 developing countries found a higher proportion of private schools in developing countries; the author argued that this higher proportion is a result of limited public spending on education that forces parents to look for alternative options (James 1993). Consistent with many US based studies, several international studies have found that students in private schools had higher academic achievement compared to public schools (Dronkers and Robert 2008; Fuchs and Wößmann 2007). In addition, analyzing the patterns of academic achievement in 22 countries using PISA 2000, Dronkers and Robert (2008) found that a large private independent sector in a country decreases the reading score of all schools in that country.

Further, Alegre and Ferrer (2010) found that as the proportion of private independent schools increases, so does the national and regional level of school segregation. In other words, a larger private sector increases between-school inequality in student achievement.

The distinction in the studies mentioned above is between developed and developing countries. Such a distinction does not fully capture the complicated national contexts in which public/private schools operate. Interestingly and somewhat surprisingly, using PISA 2006 data on 25 EU member countries, Schlicht and colleagues (2010) found that a higher share of private schools reduced the effects of social background on achievement in established Western educational systems, but not in post-socialist Eastern European countries. They found that overall educational performance of students in post-socialist countries depends more on their social background compared with the students in Western Europe. Thus, there is no consensus in the literature on the effects privatization has on inequality of academic achievement across different contexts.

Governmental Funding

Finally, an important aspect of education systems is governmental funding of schools. It has been found that higher public expenditures on education decrease educational inequality. In other words, in countries with higher investments into public education, students' performance depends less on parental characteristics (Schlicht et al. 2010; Stadelmann-Steffen 2012). Also, in countries where the government spends less on education, parents are more likely to be unsatisfied with public education and thus to seek private education, which in turn leads to a different private-public school balance in developed and developing countries (James 1993). Vegas and Coffin (2015) found that education spending is associated with increased student performance only among systems that spend below the threshold of \$8,000 per pupil.

In sum, in the current study we employed the four waves of TIMSS data in addition to the information we have collected on the countries' educational systems to examine whether different degrees of standardization, differentiation, proportion of students in private schools and governmental spending influence students' math achievement, the variation in math achievement and SES effects on math achievement.

Data and Methods

Data Source

We employed the four most recent waves of TIMSS data for 37 participating countries. TIMSS has made possible extensive, large-scale international assessments of student achievement. Since 1995, TIMSS has been conducted on a four-year cycle (i.e., 1995, 1999, 2003, 2007, and 2011). Rather than measuring student achievement against the norms of any particular national curriculum standard, the TIMSS measures student performance or "proficiency" in math and science among fourth and eighth grade students for a common international set of skills. TIMSS employs a stratified sampling design in which each participating country randomly samples the schools to be tested; one class is randomly chosen from each of these schools; and all students within the randomly selected class are tested in both math and science, yielding a nationally representative sample of students for each country (Olson et al. 2008). In addition to math and science achievement scores, TIMSS offers a variety of information on the background of students, teachers, and school principals. Given the rigorous procedures taken to ensure high-quality sampling and testing

in all countries and the standardized procedures to ensure comparability across countries, the TIMSS student performance and background data are comparable across countries and all TIMSS assessments (Olson et al. 2008).

In this study, we focused only on eighth grade students because in most countries differentiation takes place in the secondary level, thus making eighth grade students' achievement particularly important for decisions regarding track placement in secondary school. We dropped the 1995 TIMSS assessment because we were unable to find the country-specific information as to educational systems. Meanwhile, we combined data from the 1999, 2003, 2007, and 2011 TIMSS eighth-grade assessments with the country-specific information on standardization, differentiation, privatization, and governmental spending on education, as well as the Gross Domestic Production (GDP) per capita and Gini, using both international websites (e.g., EU, OECD, UNESCO, World Bank) and national governmental websites (mainly, websites of the ministries of education). We restricted our analyses to 37 countries and 69 observations where country-specific information was available. Note that for our analyses the unit of analysis was a country, not an individual student.

Measures

Dependent variables—TIMSS assesses students' knowledge of a wide array of content and cognitive domains in math and science especially based on school curricula (Olson et al. 2008). These domains reflect the nature and difficulty of math and science taught at the eighth grade level. The tests contain questions asking students to select appropriate responses or to solve problems by constructing their own answers. With the item response theory (IRT) method, both math and science proficiencies were measured by five plausible values with a scale having an international mean of 500 and an international standard deviation of 100 for each wave of TIMSS studies. In this study, we focused on math achievement.

We considered three dependent variables: (1) national average of math achievement, (2) distribution of math achievement, and (3) SES gaps in math achievement. The national average of math achievement was measured by a country's average score on the TIMSS math tests for each cycle. The distribution of math achievement was measured by a country's standard deviation of the math achievement scores for each cycle. The SES gaps in math achievement were measured by the coefficient of SES estimated from the following ordinary least squares (OLS) regression for each country and cycle:

$$\text{Math}_i = a + \text{SES}_i + r_i.$$

Where math_i indicated math achievement for i student within a country, a the intercept, and r residual errors. SES was a standardized composite score (i.e., $M = 0$, $SD = 1$) based on father's education, mother's education, and number of books for each country and cycle. Missing data on SES was replaced with a mean of SES for each country and cycle, while a dummy variable indicating missing on SES was included. Note that following the recommendations of TIMSS (Martin 2005), we simultaneously used the five plausible values of math achievement to generate correct standard errors for each country and cycle.¹

Independent variables—We relied on various international databases to collect information about degree of standardization, differentiation, privatization, and governmental spending on education. We measured *standardization* as a scale based on the following components: whether the central government controlled the curriculum (0 = no, 1 = yes) by prescribing, for example, the number of subjects, the number of hours taught, and pedagogical strategies, whether the central government prescribed textbooks (0 = no, 1 = yes), and whether students had to take a school exam at any given point that had consequences for their progression through the educational system (0 = no, 1 = yes). Values on this index (sum) range from 0 to 3 and high values indicate a high degree of standardization. We measured *differentiation* as a scale comprised of two aspects of educational systems: a number of available tracks at the secondary level and the age at which tracking occur. We use the following categories: 0 = comprehensive school (no track/mandatory selection); 1 = more than one track, late selection (age 15 and older); 2 = more than one track, early selection (age 14 and younger). We captured the country level of *privatization* by a proportion of students enrolled in non-public schools within each system (at primary and secondary level). Finally, governmental spending on education was measured by expenditure on education as % of total governmental expenditure.

Controls—We included GDP per capital and Gini coefficients as control variables.

Analysis Plan

We first examined descriptive statistics for the variables included in our analyses. Next, to address the main research question (i.e., whether institutional features of educational system are related to the national mean and distribution of math achievement, and SES-achievement gaps), we estimated a crossed random effects model (Rabe-Hesketh and Skrondal 2012; Raudenbush and Bryk 2002), given that countries were crossed with the TIMSS cycle year (i.e., 1999, 2003, 2007, and 2011).² This model was specified as follows:

$$Y_{ij} = \beta_1 + \sum_p \beta_p X_{pij} + \zeta_{1i} + \zeta_{2j} + \varepsilon_{ij}$$

where Y_{ij} is each of the dependent variables (i.e., the national mean and distribution of math achievement and SES-achievement gaps) for country i in year j ; β_{2-p} the effects of X_{2-p} variables; ζ_{1i} and ζ_{2j} random intercepts for countries i and years j , respectively; and ε_{ij} is a residual error term.

¹We used the “pv” command in Stata, which is designed to be used with the TIMSS data by allowing analysis with plausible values calculating standard errors with Jackknife replicate weights. For more information about this command, see <https://ideas.repec.org/c/boc/bocode/s456951.html>.

²We treated our data as cross-classified data, where the country subject is crossed with occasion (i.e., TIMSS cycle year), rather than nested data, where the country subject is nested within occasion. Thus, we believe the crossed random effects model is more appropriate than the random effects model because it is more reasonable to consider a random main effect of occasion (see Rabe-Hesketh and Skrondal 2012).

Results

Descriptive Results

Table 1 presents descriptive statistics for the variables included in our analyses by country and TIMMS cycle year. To briefly summarize, when it came to the national mean of math achievement, some countries showed an increasing trend, whereas other countries showed the opposite. For example, the national average math achievement for Israel was 469 in 1999 but it increased to 512 in 2011. By contrast, in Hungary it was 537 in 1999 but decreased to 511 in 2011. This was also the case for the distribution of math achievement. For example, the standard deviation of math achievement for Thailand was 85 in 1999 but it increased to 92 in 2011. In Indonesia it was 102 in 1999 but it decreased to 84 in 2011. The SES gaps in math achievement also showed a divergent trend. For example, one standard deviation increase in the index of SES was associated with a 38-point increase in math achievement in 1999 for Israel, but the corresponding increase was a 48 point in 2011, indicating the growing SES gap in math achievement between 1999 and 2011. In contrast, Italy in 1999 showed a 28-point SES difference, but it decreased to a 25 point in 2011, indicating the closing SES gap in this country.

When it came to different aspects of educational systems, results also showed a divergent trend. For instance, the degree of standardization decreased between 1999 and 2011 for Israel, whereas there was no change in Italy for the same period. For the number of tracks, only Chile and Israel showed a decreasing trend (Israel had 3 tracks in 1999 but 2 in 2011). There was no change in the number of tracks for other countries. Likewise, there were only a few countries showing a change in the age at which tracking occurs. Regarding the percent of students attending private schools, a few countries showed an increasing trend. For example, the percent of students attending private schools was 46% in 1999 for Chile but it increased to 59% in 2011. Finally, in terms of governmental spending on education, there was a varying trend as well. For example, Indonesia increased the governmental expenditure on education between 1999 and 2011, whereas Italy showed the opposite trend.

Results from the Crossed Random Effects Model

Table 2 presents the results from the crossed random effects model. The first column displays the results for the national mean of math achievement as the dependent variable. The findings showed that standardization was positively and significantly related to the national mean of math achievement. That is, a higher degree of standardization in a country was associated with a higher national average of math achievement. In calculations not shown we found that having a standardized textbook for math was particularly associated with higher average math achievement in a country. GDP per capita was positively associated with average math achievement, suggesting that students in wealthier countries performed better than their counterparts in less fortunate countries. Gini coefficient was negatively associated with average achievement, suggesting that higher levels of economic inequality are associated with lower levels of math achievement.

The second column of Table 2 displays the results for the variation in math achievement as the dependent variable. Our analysis did not indicate any significant relationships between

standardization, differentiation, and privatization and variation in math achievement. Interestingly, the expenditure on education as % of total government spending was significantly and negatively associated with the distribution of math achievement. In other words, higher governmental spending on education was associated with a smaller variation in math achievement within a country. In addition, higher GDP per capita was associated with a smaller variation in math achievement, whereas higher Gini was associated with greater variation.

Finally, the last column of Table 2 presents the results for the SES-achievement gap as the dependent variable. Our findings showed that governmental spending on education was significantly and negatively associated with the SES-achievement gap. In other words, in a country that is spending a higher proportion of its governmental funds on education, the SES-achievement gap was smaller. Gini was positively associated with the SES-achievement gap, suggesting that a country with higher income inequality has greater SES-achievement gap.

Next, we investigated the interaction between standardization and differentiation. Table 3 presents the results for the interaction effects. Results showed that in highly differentiated countries, having higher degree of standardization increases the average achievement. In other words, in countries with rigid tracking and especially in those that track their students early, having standardized curriculum, textbooks and national exams helps to alleviate the negative effects of differentiation.

Discussion

We utilized the four waves of TIMSS data in addition to the information we have collected on the countries' educational systems to examine whether different degrees of standardization, differentiation, proportion of students in private schools and governmental spending on education influence students' math achievement, the variation in math achievement and SES effects on math achievement. Examining the patterns of relationships between specific aspects of educational policy and student achievement, as well as to what extent these aspects of educational policy moderate the relationship between family SES and student achievement is an important investigation.

Consistent with the existing literature, our analysis of TIMSS data showed that a higher level of standardization of educational systems was associated with higher average math achievement. When we analyzed separately the measures of standardization, having governmentally prescribed textbooks was positively associated with average math achievement and negatively associated with SES gaps in achievement. These findings are important given the increased popularity of decentralization measures in many national educational systems (Busemeyer, 2012). Our findings suggest that this trend might be detrimental to overall student performance and might lead to an increase in inequality. With that said, it is entirely possible that, as Litvack et al (1998) pointed out in their extensive report on decentralization, "decentralization is an issue about which it may truly be said that 'the devil is in the details'(p. 30)."

We found that greater expenditure on education (as % of total government expenditure) was associated with a lower level of dispersion of math achievement and smaller SES gaps in math achievement. Further, wealthier countries exhibit higher average math achievement and smaller variation in math achievement. By contrast, we found that higher income inequality (measured by Gini index) was associated with a lower average math achievement, a higher level of dispersion of math achievement and greater SES gaps.

Overall, although our investigation produced several significant findings, it also became clear that it is hard to describe a “golden model of education,” discerning parameters that would produce the most effective and efficient academic results across different national contexts. Educational systems are deeply embedded within the economic, political, social and cultural realities of their countries. As such, not only the models of privatization, funding mechanisms, the circumstances of tracking, and shaping curriculum and assessment vary greatly across countries, but they also produce different results in different contexts. As such, our findings agree with Schlicht and colleagues (2010) who found varying effects across different countries. That being said, we are confident that higher standardization is associated with increased national average in math achievement, and higher governmental spending is associated with decreased socio-economic gaps in achievement. Furthermore, the analysis of the interaction effects revealed that high standardization alleviates the negative influence of rigid tracking, particularly in the systems that differentiate their students at the early age.

Our study is based on 37 countries for which we could find extensive information on their educational systems. The obvious limitation that follows is that we could not maximize the use of TIMSS data on all participating countries. Future studies can build upon our investigation and supplement our data with completion of data for the rest of participating countries. The current investigation was focused on socioeconomic inequality and whether and how countries’ institutional characteristics moderate the SES gaps in math achievement. Another promising direction is to examine gender differences in math achievement under different educational systems’ features. Furthermore, it is important to investigate to what extent the individual students’ experiences are shaped by the macro characteristics of the educational systems.

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References

- Akiba, Motoko, LeTendre, Gerald K., Scribner, Jay P. Teacher Quality, Opportunity Gap, and National Achievement in 46 Countries. *Educational Researcher*. 2007; 36(7):369–87. DOI: 10.3102/0013189x07308739
- Alegre, Miquel Angel, Ferrer, Gerard. School Regimes and Education Equity: Some Insights Based on PISA 2006. *British Educational Research Journal*. 2010; 36(3):433–461. DOI: 10.1080/01411920902989193
- Alexander, Karl L., Cook, Martha, McDill, Edward L. Curriculum Tracking and Educational Stratification: Some Further Evidence. *American Sociological Review*. 1978; 43(1):47–66. DOI: 10.1037/e404312004-001
- Ammermüller, Andreas, Heijke, Hans, Wößmann, Ludger. Schooling Quality in Eastern Europe: Educational Production During Transition. *Economics of Education Review*. 2005; 24(5):579–599. DOI: 10.1016/j.econedurev.2004.08.010
- Ayalon, Hanna, Gamoran, Adam. Stratification in Academic Secondary Programs and Educational Inequality in Israel and the United States. *Comparative Education Review*. 2000; 44(1):54–80. DOI: 10.1086/447591
- Barone, Carlo. Cultural Capital, Ambition and the Explanation of Inequalities in Learning Outcomes: A Comparative Analysis. *Sociology*. 2006; 40(6):1039–1058. DOI: 10.1177/0038038506069843
- Bemstein, Basil. *Class, Codes and Control*. Abingdon: Routledge; 1975.
- Bishop, John H. The Effect of National Standards and Curriculum-based Exams on Achievement. *The American Economic Review*. 1997; 87(2):260–264.
- Bishop, John H., Wößmann, Ludger. Institutional Effects in a Simple Model of Educational Production. *Education Economics*. 2004; 12(1):17–38. DOI: 10.1080/0964529042000193934
- Blau, Peter M., Duncan, Otis Dudley. *The American Occupational Structure*. New York: The Free Press; 1967.
- Bodovski, Katerina. Parental Practices and Educational Achievement: Social Class, Race, and Habitus. *British Journal of Sociology of Education*. 2010; 31(2):139–156. DOI: 10.1080/01425690903539024
- Bodovski, Katerina, Kotok, Stephen, Henck, Adrienne. Universal Patterns or the Tale of Two Systems? Mathematics Achievement and Educational Expectations in Post-Socialist Europe. *Compare: A Journal of Comparative and International Education*. 2014; 44(5):732–755. DOI: 10.1080/03057925.2013.792670
- Bol, Thijs, Witschge, Jacqueline, Van de Werfhorst, Herman G., Dronkers, Jaap. Curricular Tracking and Central Examinations: Counterbalancing the Impact of Social Background on Student Achievement in 36 Countries. *Social Forces*. 2014; 92(4):1545–1572. DOI: 10.1093/sf/sou003
- Bourdieu, Pierre. The Forms of Capital. In: Richardson, John, editor. *Handbook of Theory and Research for the Sociology of Education*. New York: Greenwood Press; 1986. p. 241–258.
- Samuel, Bowles, Gintis, Herbert. *Schooling in Capitalist America: Educational Reform and the Contradictions of Economic Life*. New York: Basic Books; 1976.
- Brunello, Giorgio, Checchi, Daniele. Does School Tracking Affect Equality of Opportunity? New International Evidence. *Economic policy*. 2007; 22(52):782–861. DOI: 10.1111/j.1468-0327.2007.00189.x
- Buchmann, Claudia, Park, Hyunjoon. Stratification and the Formation of Expectations in Highly Differentiated Educational Systems. *Research in Social Stratification and Mobility*. 2009; 27(4): 245–267. DOI: 10.1016/j.rssm.2009.10.003
- Bussemeyer, MR. Two decades of decentralization in education governance: Lessons learned and future outlook for local stakeholders. Paper presented at the meeting of OECD conference ‘Effective local governance in education,’; Warsaw, Poland. 2012 Apr. Retrieved from http://www.forschungsnetzwerk.at/downloadpub/50293543_Two_decades_of_decentralization_in_education_governance.pdf
- Byun, Soo-yong, Kim, Kyung-keun. Educational Inequality in South Korea: The Widening Socioeconomic Gap In Student Achievement. *Research in the Sociology of Education*. 2010; 17:155–182. DOI: 10.1108/s1479-3539(2010)0000017008

- Carnoy, Martin, Loeb, Susanna. Does External Accountability Affect Student Outcomes? A Cross-state Analysis. *Educational Evaluation and Policy Analysis*. 2002; 24(4):305–331. DOI: 10.3102/01623737024004305
- Clune, William H. The Best Path To Systemic Educational Policy: Standard/centralized or Differentiated/decentralized? *Educational Evaluation and Policy Analysis*. 1993; 15(3):233–254. DOI: 10.3102/01623737015003233
- Combet B. How The Education System Moderates Parents' Influence on Their Child's Track Choice in Switzerland. Working paper. 2015
- Dauber, Susan L., Alexander, Karl L., Entwisle, Doris R. Tracking and Transitions Through the Middle Grades: Channeling Educational Trajectories. *Sociology of Education*. 1996; 69(4):290–307. DOI: 10.2307/2112716
- Dronkers, Jaap, Robert, Péter. Differences in Scholastic Achievement of Public, Private Government-dependent, and Private Independent Schools a Cross-National Analysis. *Educational Policy*. 2008; 22(4):541–577. DOI: 10.1177/0895904807307065
- English, Fenwick W., Steffy, Betty E. Deep Curriculum Alignment: Creating a Level Playing Field For All Children On High-stakes Tests of Educational Accountability. Lanham: Rowman & Littlefield Education; 2001.
- Farkas, George. Cognitive Skills and Noncognitive Traits and Behaviors in Stratification Processes. *Annual Review of Sociology*. 2003; 29:541–562. DOI: 10.1146/annurev.soc.29.010202.100023
- Fuchs, Thomas, Wößmann, Ludger. What Accounts For International Differences in Student Performance? A re-examination Using PISA Data. *Empirical Economics*. 2007; 32(2):433–464. DOI: 10.1007/978-3-7908-2022-5_10
- Gamoran, Adam. The Stratification of High School Learning Opportunities. *Sociology of Education*. 1987; 60(3):135–155. DOI: 10.2307/2112271
- Gamoran, Adam. The Variable Effects of High School Tracking. *American Sociological Review*. 1992; 57(6):812–828. DOI: 10.2307/2096125
- Gamoran, Adam. Student Achievement in Public Magnet, Public Comprehensive, and Private City High Schools. *Educational Evaluation and Policy Analysis*. 1996; 18(1):1–18. DOI: 10.3102/01623737018001001
- Gamoran, Adam, Mare, Robert D. Secondary School Tracking and Educational Inequality: Compensation, Reinforcement, or Neutrality? *American Journal of Sociology*. 1989; 94(5):1146–1183. DOI: 10.1086/229114
- Gerber, Theodore P. Educational Stratification in Contemporary Russia: Stability and Change in the Face of Economic and Institutional Crisis. *Sociology of Education*. 2000; 73(4):219–246. DOI: 10.2307/2673232
- Gerber, Theodore P., Hout, Michael. Educational Stratification in Russia During the Soviet Period. *American Journal of Sociology*. 1995; 101(3):611–660. DOI: 10.1086/230755
- Gerber, Theodore P., Hout, Michael. Tightening Up: Declining Class Mobility During Russia's Market Transition. *American Sociological Review*. 2004; 69(5):677–703. DOI: 10.1177/000312240406900504
- Hallinan, Maureen T. Tracking: From Theory to Practice. *Sociology of Education*. 1994; 67(2):79–84. DOI: 10.2307/2112697
- Hallinan, Maureen T. Ability Grouping and Student Learning. *Brookings Papers on Education Policy*. 2003; 6:95–124. DOI: 10.1353/pep.2003.0005
- Hanushek, Eric A., Wößmann, Ludger. Does Educational Tracking Affect Performance and Inequality? Differences-in-differences Evidence Across Countries. *The Economic Journal*. 2006; 116(510):C63–C76. DOI: 10.1111/j.1468-0297.2006.01076.x
- Horn, Daniel. Age of Selection Counts: A Cross-Country Analysis of Educational Institutions. *Educational Research and Evaluation*. 2009; 15(4):343–366. DOI: 10.1080/13803610903087011
- Jakubowski, Maciej. Institutional Tracking and Achievement Growth: Exploring Difference-in-Differences Approach to PIRLS, TIMSS, and PISA Data. In: Dronkers, Jaap, editor. *Quality and Inequality of Education*. Netherlands: Springer; 2010. p. 41–81.
- James, Estelle. Why do Different Countries Choose a Different Public-Private Mix of Educational Services? *The Journal of Human Resources*. 1993; 28(3):571–592. DOI: 10.2307/146161

- Kerckhoff, Alan. Effects of Ability Grouping in British Secondary Schools. *American Sociological Review*. 1986; 51(6):842–858. <http://www.jstor.org/stable/2095371>.
- Kerckhoff, Alan. Institutional Arrangements and Stratification Processes in Industrial Societies. *Annual Review of Sociology*. 1995; 21:323–347. DOI: 10.1146/annurev.so.21.080195.001543
- Kerckhoff, Alan. Education and Social Stratification Processes in Comparative Perspective. *Sociology of Education*. 2001; 74:3–18. (Special issue: Current of Thought: Sociology of Education at the Dawn of the 21st Century). DOI: 10.2307/2673250
- Lareau, Annette. *Home Advantage: Social Class and Parental Intervention in Elementary Education*. Lanham: Rowman and Littlefield; 2000.
- Lareau, Annette. *Unequal Childhoods: Class, Race, and Family Life*. Berkeley: University of California Press; 2003.
- Levels, Mark, Dronkers, Jaap, Kraaykamp, Gerbert. Immigrant Children's Educational Achievement in Western Countries: Origin, Destination, and Community Effects on Mathematical Performance. *American Sociological Review*. 2008; 73(5):835–853. DOI: 10.1177/000312240807300507
- Litvack, JI., Ahmad, J., Bird, RM. Rethinking decentralization in developing countries. World Bank Sector Studies Series. 1998. Retrieved from <http://www1.worldbank.org/publicsector/decentralization/Rethinking%20Decentralization.pdf>
- Marks, Gary. Cross-national Differences and Accounting for Social Class Inequalities in Education. *International Sociology*. 2005; 20(4):483–505. DOI: 10.1177/0268580905058328
- Marks, Gary. Are Between- and Within-school Differences in Student Performance Largely Due to Socio-economic Background? Evidence from 30 countries. *Educational Research*. 2006; 48(1):21–40. DOI: 10.1080/00131880500498396
- Martin, Michael O., editor. *TIMSS 2003 User Guider for the International Database*. Chestnut Hill, MA: TIMSS & PIRLS International Study Center, Boston College; 2005.
- Mateju, Petr. Who Won and Who Lost in a Socialist Redistribution in Czechoslovakia?. In: Shavit, Yossi, Blossfeld, Hans-Peter, editors. *Persistent inequality. Changing Educational Attainment in Thirteen Countries*. Boulder: Westview Press; 1993. p. 251–271.
- Oakes, Jeannie. *Keeping Track: How Schools Structure Inequality*. New Haven: Yale University Press; 2005.
- Olson, John, Martin, Michael, Mullis, Ina, editors. *TIMSS 2007 Technical Report*. Chestnut Hill: TIMSS & PIRLS International Study Center, Boston College; 2008.
- Park, Hyunjoon. The Varied Educational Effects of Parent-Child Communication: A Comparative Study of Fourteen Countries. *Comparative Education Review*. 2008; 52(2):219–243. DOI: 10.1086/528763
- Rabe-Hesketh, Sophia, Skrondal, Anders. *Multilevel and Longitudinal Modeling Using Stata. Volume I: Continuous Responses*. 3. College Station, TX: Stata Press; 2012.
- Raudenbush, Stephe, Bryk, Anthony. *Hierarchical Linear Models: Applications and Data Analysis Methods (Advanced Quantitative Techniques in the Social Sciences Series)*. London: SAGE; 2002.
- Scheerens, Jaap. What is Effective Schooling? A Review of Current Thought and Practice. *International Baccalaureate Organization*; 2013.
- Schlicht, Raphaela, Stadelmann-Steffen, Isabelle, Freitag, Marcus. Educational Inequality in the EU: The Effectiveness of the National Education Policy. *European Union Politics*. 2010; 11(1):29–59. DOI: 10.1177/1465116509346387
- Schutz, Gabriela, West, Martin, Wößmann, Ludger. Education working paper #14. Paris: OECD Publishing; 2007. *School Accountability, Autonomy, Choice, and the Equity of Student Achievement: International Evidence from PISA 2003*.
- Shavit, Yossi, Blossfeld, Hans-Peter. *Persistent Inequality. Changing Educational Attainment in Thirteen Countries*. Boulder: Westview Press; 1993.
- Sewell, William, Haller, Archibald, Ohlendorf, George. The Educational and Early Occupational Status Attainment Process: Replication and Revision. *American Sociological Review*. 1970; 35:1014–1027. <http://www.jstor.org/stable/2093379>.
- Sewell, William, Hauser, Robert. Causes and Consequences of Higher Education: Models of the Status Attainment Process. *American Journal of Agricultural Economics*. 1976; 54(5):851–861. DOI: 10.2307/1239228

- Stadelmann-Steffen, Isabelle. Education Policy and Educational Inequality - Evidence from the Swiss Laboratory. *European Sociological Review*. 2012; 28(3):379–393. DOI: 10.1093/esr/jcq071
- Szelenyi, Szonja, Aschaffenburg, Karen. Inequalities in Educational Opportunity in Hungary. In: Shavit, Yossi, Blossfeld, Hans-Peter, editors. *Persistent Inequality: Changing Educational Attainment in Thirteen Countries*. Boulder: Westview Press; 1993. p. 273-302.
- Trusty, Jerry. Effects of High School Course-taking and Other Variables on Choice of Science and Mathematics College Majors. *Journal of Counseling & Development*. 2002; 80(4):464–474. DOI: 10.1002/j.1556-6678.2002.tb00213.x
- Tyson, Will, Lee, Reginald, Borman, Kathryn M., Hanson, Mary Ann. Science, Technology, Engineering, and Mathematics (STEM) Pathways: High School Science and Math Coursework and Postsecondary Degree Attainment. *Journal of Education for Students Placed at Risk*. 2007; 12(3): 243–270. DOI: 10.1080/10824660701601266
- Van de Werfhorst, Herman, Mijs, Jonathan. Achievement Inequality and the Institutional Structure of Educational Systems: A Comparative Perspective. *Annual Review of Sociology*. 2010; 36:407–428. DOI: 10.1146/annurev.soc.012809.102538
- Vegas, Emiliana, Coffin, Chelsea. When Education Expenditure Matters: An Empirical Analysis of Recent International Data. *Comparative Education Review*. 2015; 59(2):289–304. DOI: 10.1086/680324
- Vulliamy, Graham, Webb, Rosemary. The Implementation of the National Curriculum in Small Primary Schools. *Educational Review*. 1995; 47(1):25–41. DOI: 10.1080/0013191950470103
- Walberg, Herbert J., Paik, Susan J., Komukai, Atsuko, Freeman, Karen. Decentralization: An International Perspective. *Educational Horizons*. 2000; 1:155–166. <http://www.jstor.org/stable/42925360>.
- Willms, Jon Douglas. *UIS Working Paper #5*. Montreal: UNESCO Institute for Statistics; 2006. *Learning Divides: Ten Policy Questions about the Performance and Equity of Schools and Schooling Systems*.

Table 1

Descriptive Statistics of Variables Included in Analyses by Country and TIMSS cycle

Country	TIMSS Cycle	Average math achievement	Distribution of math achievement	SES gaps in math achievement
Armenia	2011	472.2	90.5	22.0
Australia	2007	495.2	78.7	33.5
Australia	2011	495.9	85.9	48.6
Chile	1999	393.2	83.9	43.5
Chile	2011	431.2	85.2	35.5
Colombia	2007	380.4	78.4	28.8
Czech Republic	1999	556.9	87.3	25.2
Czech Republic	2007	506.1	73.7	28.1
El Salvador	2007	346.5	72.5	23.3
England	2003	506.6	80.2	24.1
England	2011	510.0	85.8	35.3
Finland	2011	514.2	65.5	22.5
Georgia	2011	437.5	105.2	40.4
Ghana	2011	333.0	86.3	11.2
Hong Kong	2007	577.2	92.0	20.1
Hong Kong	2011	587.4	84.4	25.4
Hungary	1999	536.7	84.7	39.6
Hungary	2003	532.5	80.4	50.6
Hungary	2007	522.9	85.2	42.9
Hungary	2011	513.5	85.3	48.5
Indonesia	1999	405.8	102.5	31.1
Indonesia	2007	402.7	89.3	29.0
Indonesia	2011	400.5	83.6	19.7
Iran, Islamic Rep.	2011	419.1	94.8	44.5
Israel	1999	468.7	94.9	37.5
Israel	2011	512.2	99.6	48.4
Italy	1999	480.2	86.1	28.4
Italy	2003	482.9	76.3	26.6
Italy	2007	480.4	76.2	24.4
Italy	2011	498.7	72.6	25.0
Japan	2003	568.9	79.4	31.2
Japan	2007	572.3	86.0	36.2
Japan	2011	571.0	85.1	32.2
Kazakhstan	2011	484.2	80.5	17.4
Korea	1999	587.8	79.2	23.9
Korea	2007	598.0	91.9	33.3
Korea	2011	614.5	89.9	35.6
Lithuania	2007	511.2	79.0	33.5
Lithuania	2011	508.9	77.4	32.8

Country	TIMSS Cycle	Average math achievement	Distribution of math achievement	SES gaps in math achievement
Macedonia, Rep. of	1999	448.0	92.5	43.6
Malaysia	2011	440.8	91.8	32.7
Netherlands	1999	547.0	69.1	19.6
Netherlands	2003	540.5	68.3	23.3
New Zealand	2003	488.0	77.2	27.3
New Zealand	2011	484.6	84.0	35.7
Norway	2003	460.7	71.3	25.0
Norway	2007	469.6	65.6	21.6
Norway	2011	476.5	65.0	22.1
Romania	2007	472.2	96.9	40.2
Romania	2011	469.3	103.8	50.8
Russian Federation	2007	519.7	83.3	32.8
Russian Federation	2011	542.6	80.7	27.1
Singapore	2011	607.5	83.9	30.4
Slovak Republic	2003	522.7	88.0	36.3
Slovenia	2007	503.5	71.1	25.3
Slovenia	2011	504.7	70.4	27.3
South Africa	2011	366.7	90.4	37.6
Sweden	2003	499.0	71.9	28.0
Sweden	2007	493.2	70.1	24.1
Sweden	2011	483.4	67.9	23.2
Thailand	1999	471.8	85.3	29.1
Thailand	2007	448.4	92.2	38.5
Thailand	2011	441.6	92.3	30.7
Tunisia	2007	422.3	66.4	21.0
Tunisia	2011	419.9	76.6	26.8
Turkey	2007	437.8	112.7	52.9
Ukraine	2011	488.1	87.9	36.8
United States	2003	504.2	80.3	36.4
United States	2007	506.2	77.7	31.9

Country	TIMSS Cycle	Standardization	Differentiation	% of students enrolling in private schools
Armenia	2011	3	2	1.7
Australia	2007	1	1	31.3
Australia	2011	2	1	35.2
Chile	1999	3	2	45.9
Chile	2011	3	1	59.0
Colombia	2007	1	2	24.1
Czech Republic	1999	3	3	5.8
Czech Republic	2007	2	3	7.8
El Salvador	2007	3	2	18.5
England	2003	2	1	26.3
England	2011	2	1	29.4

Country	TIMSS Cycle	Standardization	Differentiation	% of students enrolling in private schools
Finland	2011	1	1	9.4
Georgia	2011	3	3	6.4
Ghana	2011	3	2	15.4
Hong Kong	2007	3	2	13.9
Hong Kong	2011	3	2	16.7
Hungary	1999	3	3	6.4
Hungary	2003	3	3	10.3
Hungary	2007	2	3	10.8
Hungary	2011	2	3	13.4
Indonesia	1999	3	1	44.1
Indonesia	2007	2	1	47.1
Indonesia	2011	2	1	41.4
Iran, Islamic Rep.	2011	2	2	11.9
Israel	1999	3	3	0.0
Israel	2011	2	2	11.9
Italy	1999	2	3	5.9
Italy	2003	2	3	5.0
Italy	2007	2	3	5.0
Italy	2011	2	3	8.5
Japan	2003	2	2	18.7
Japan	2007	3	2	19.1
Japan	2011	3	2	19.2
Kazakhstan	2011	3	2	5.1
Korea	1999	3	3	40.8
Korea	2007	3	3	32.1
Korea	2011	3	3	31.5
Lithuania	2007	3	2	0.6
Lithuania	2011	3	2	1.3
Macedonia, Rep. of	1999	3	3	0.0
Malaysia	2011	3	2	4.7
Netherlands	1999	2	3	76.6
Netherlands	2003	2	3	74.4
New Zealand	2003	2	1	10.0
New Zealand	2011	2	1	10.9
Norway	2003	3	1	6.4
Norway	2007	2	1	6.6
Norway	2011	2	1	8.2
Romania	2007	3	3	1.0
Romania	2011	3	3	1.8
Russian Federation	2007	3	3	0.6
Russian Federation	2011	3	3	0.8
Singapore	2011	3	3	6.4
Slovak Republic	2003	3	3	6.4

Country	TIMSS Cycle	Standardization	Differentiation	% of students enrolling in private schools
Slovenia	2007	3	3	1.4
Slovenia	2011	3	3	1.5
South Africa	2011	3	1	3.2
Sweden	2003	1	1	3.9
Sweden	2007	1	1	12.1
Sweden	2011	1	1	19.4
Thailand	1999	3	3	12.9
Thailand	2007	2	2	18.0
Thailand	2011	2	2	16.2
Tunisia	2007	3	1	4.7
Tunisia	2011	3	1	4.8
Turkey	2007	3	3	2.0
Ukraine	2011	3	2	0.4
United States	2003	2	1	9.2
United States	2007	2	1	8.8

Country	TIMSS Cycle	Expenditure on education as % of total gov. expenditure	GDP per capita (logged)	Gini
Armenia	2011	12.6	8.1	31.3
Australia	2007	13.0	10.6	30.3
Australia	2011	13.5	11.0	32.0
Chile	1999	15.6	8.5	55.5
Chile	2011	17.5	9.6	50.8
Colombia	2007	14.5	8.4	59.4
Czech Republic	1999	9.1	8.7	23.8
Czech Republic	2007	9.9	9.8	25.7
El Salvador	2007	16.9	8.1	45.2
England	2003	13.9	10.4	33.5
England	2011	13.1	10.6	38.0
Finland	2011	11.9	10.8	27.7
Georgia	2011	9.3	8.2	41.6
Ghana	2011	33.4	7.4	42.3
Hong Kong	2007	22.2	10.3	53.3
Hong Kong	2011	17.4	10.5	53.7
Hungary	1999	9.9	8.5	27.8
Hungary	2003	11.9	9.0	30.9
Hungary	2007	10.4	9.5	28.3
Hungary	2011	9.4	9.5	28.9
Indonesia	1999	7.7	6.5	29.0
Indonesia	2007	14.9	7.5	34.0
Indonesia	2011	16.7	8.2	38.1
Iran, Islamic Rep.	2011	15.6	8.9	42.0
Israel	1999	12.7	9.8	38.1
Israel	2011	13.5	10.4	37.7

Country	TIMSS Cycle	Expenditure on education as % of total gov. expenditure	GDP per capita (logged)	Gini
Italy	1999	9.2	10.0	37.6
Italy	2003	9.2	10.2	37.3
Italy	2007	8.4	10.5	35.5
Italy	2011	8.0	10.5	32.2
Japan	2003	9.9	10.4	30.8
Japan	2007	10.0	10.4	32.9
Japan	2011	9.7	10.7	33.6
Kazakhstan	2011	13.0	9.3	27.4
Korea	1999	13.1	9.3	28.8
Korea	2007	15.3	10.0	31.2
Korea	2011	14.8	10.1	31.1
Lithuania	2007	13.3	9.4	34.4
Lithuania	2011	13.6	9.6	32.6
Macedonia, Rep. of	1999	20.0	7.5	27.7
Malaysia	2011	21.0	9.2	46.2
Netherlands	1999	10.6	10.2	28.1
Netherlands	2003	11.5	10.4	31.1
New Zealand	2003	19.7	10.0	33.5
New Zealand	2011	17.9	10.5	35.1
Norway	2003	15.8	10.8	30.2
Norway	2007	16.6	11.3	26.5
Norway	2011	15.0	11.5	25.0
Romania	2007	12.0	9.0	30.4
Romania	2011	8.3	9.1	27.2
Russian Federation	2007	12.4	9.1	39.3
Russian Federation	2011	11.1	9.5	39.6
Singapore	2011	19.5	10.9	47.3
Slovak Republic	2003	10.7	9.1	29.1
Slovenia	2007	12.9	10.1	24.1
Slovenia	2011	12.1	10.1	24.9
South Africa	2011	18.9	9.0	65.0
Sweden	2003	13.0	10.5	23.4
Sweden	2007	12.9	10.8	25.9
Sweden	2011	13.2	10.9	27.3
Thailand	1999	20.1	7.6	43.1
Thailand	2007	18.0	8.2	42.4
Thailand	2011	24.1	8.6	39.4
Tunisia	2007	22.0	8.2	37.7
Tunisia	2011	20.1	8.4	35.8
Turkey	2007	8.6	9.1	38.4
Ukraine	2011	13.5	8.2	24.6
United States	2003	16.4	10.6	37.4
United States	2007	15.5	10.8	41.6

Table 2

Maximum Likelihood Estimates of the Crossed Random Effects Model Predicting National Mean, Standard Deviation, and SES Gaps in Math Achievement

	M		SD		SES math achievement gap	
	B	SE	B	SE	B	SE
<i>Fixed part</i>						
Standardization	22.47 **	6.69	2.88	1.89	0.03	1.81
Differentiation	12.00	7.46	-0.11	1.76	0.20	1.70
% of students enrolling in private schools	0.31	0.37	-0.07	0.08	-0.08	0.08
Expenditure on education as % of total gov. expenditure	-1.23	1.09	-0.58 *	0.28	-0.90 **	0.27
GDP per capita (logged)	29.24 ***	5.04	-2.77 *	1.24	-0.17	1.18
Gini	-2.06 **	0.63	0.26 [†]	0.14	0.29 *	0.14
Constant	211.70 **	64.49	102.94 ***	16.27	36.46 *	15.62
<i>Random part</i>						
Country	37.997		6.979		6.797	
Year	0.000		0.649		0.090	
Residuals	13.623		4.832		4.615	
Log likelihood	-327.106		-235.065		-232.130	
N of observations	69		69		69	
N of countries	37		37		37	

*** p<.001,

** p<.01,

* p<.05,

[†] p<.10 (two-tailed tests)

Table 3
Models Predicting National Mean, Standard Deviation, and SES Gaps in Math Achievement with the Interaction Effects

	M		SD		SES math achievement gap	
	B	SE	B	SE	B	SE
<i>Fixed part</i>						
Standardization	-11.26	13.64	6.26	4.14	1.26	3.99
Differentiation	-35.23 [†]	18.10	3.99	5.32	1.81	5.13
% of students enrolling in private schools	0.46	0.37	-0.09	0.08	-0.09	0.08
Expenditure on education as % of total gov. expenditure	-1.71	1.05	-0.56 [†]	0.28	-0.89 ^{**}	0.27
GDP per capita (logged)	26.86 ^{***}	4.81	-2.51 [*]	1.26	-0.10	1.19
Gini	-1.91 ^{**}	0.62	0.23	0.15	0.28 [*]	0.14
Standardization X Differentiation	16.89 ^{**}	6.21	-1.76	1.97	-0.65	1.91
Constant	324.39 ^{***}	68.26	94.27 ^{***}	18.84	33.17 [†]	17.92
<i>Random part</i>						
Country	39.111		7.482		6.919	
Year	0.000		0.442		0.000	
Residuals	12.028		4.580		4.552	
Log likelihood	-323.808		-234.802		-232.081	
N of observations	69		69		69	
N of countries	37		37		37	

^{***} p<.001,

^{**} p<.01,

^{*} p<.05,

[†] p<.10 (two-tailed tests)