How Equal Are Educational Opportunities?
Family Background and Student Achievement
in Europe and the United States

Ludger Wößmann

ifo Institute for Economic Research,
University of Munich,
CESifo and IZA
Poschingerstr. 5
81679 Munich, Germany
Phone: (+49) 89 / 9224-1699
E-mail: woessmann@ifo.de
Internet: www.cesifo.de/link/woessmann_l.htm

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Abstract

This paper estimates the effects of family background on student performance in the US and 17 Western European school systems. Family background has strong effects both in Europe and the United States, remarkably similar in size. France and Flemish Belgium achieve the most equitable performance for students from different family backgrounds, and Britain and Germany the least. Equality of opportunities is unrelated to countries' mean performance. Quantile regressions show little variation in family-background effects across the ability distribution in most countries.

1. Introduction

Equality of opportunity for all citizens is a major concern in all open societies (cf., e.g., Roemer 1998). The education system lays an important foundation for the future civil, social, and economic opportunities of citizens. In the economic sphere, abundant research has shown the importance of educational performance for the future income and productivity of individuals and societies (cf., e.g., Bishop 1992; Card 1999). However, no consistent evidence is available to what extent different countries achieve equal educational opportunities for children from different family backgrounds. Such evidence would be useful both because it could reveal an important feature of each country's equality of opportunity and because the comparison of equality of educational opportunity across countries may lead to a better understanding of how it may be achieved and why different countries achieve it to a different extent. It is the aim of this paper to present estimates of the extent of equality of opportunity in education in Western European countries and the United States that are directly comparable across countries.

The topic of equality of educational opportunity directly relates to the economic literature on intergenerational earnings mobility, which looks at the relation in earnings between parents and their children. Because of the strong relation between education and earnings, there should be a strong mapping between intergenerational mobility in education outcomes and intergenerational mobility in earnings. But while Solon (2002) shows how the literature on earnings mobility suffers from limitations in the comparability of data and concepts across countries, this paper uses internationally comparable data on students' educational performance to yield readily comparable estimates of educational mobility. Measures of intergenerational educational mobility have the additional advantage over measures of earnings mobility of providing contemporaneous evidence on family-background effects on children currently in school, while earnings mobility can only be measured with sufficient precision once the children have been in the labor market for a considerable period of time.

Evidence of substantial earnings returns to quantitative measures of education, like years of schooling, is abundant (cf. the surveys by Card 1999 and Ashenfelter et al. 1999).[1] But the earnings returns to qualitative measures of education, like scores on cognitive achievement tests, seem to be even higher (Boissiere et al. 1985; Bishop 1989, 1992) and increasing over time (Murnane et al. 1995). Furthermore, while returns to educational quantity decrease over

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[1] Ermisch and Francesconi (2001) study the impact of family background on educational quantity in Britain.

time in the labor market, returns to educational quality increase over time (Altonji and Pierret 2001). Even among school dropouts, i.e. students with the lowest educational quantity, there are substantial earnings returns to basic cognitive skills (Tyler et al. 2000).[2] This suggests that qualitative measures of education such as cognitive achievement tests are better indicators for future economic opportunities than quantitative measures of education such as years of formal schooling.

Therefore, this paper uses data from a large international comparative student achievement test – the Third International Mathematics and Science Study (TIMSS) – to estimate the impact of parental education and other measures of family background on children's test scores. Thus, for the purposes of this paper, the extent of equality of opportunity in education is measured by the size of the effect that several measures of students' family background have on their performance on standardized achievement tests in math and science.

In effect, the estimates of equality of educational opportunity are derived by estimating the "home production" part of education production functions.[3] The TIMSS database contains both achievement data for representative samples of middle-school students in 17 Western European school systems (in 15 countries) and the United States, and abundant family-background data available from student background questionnaires. The fact that the same data-generating process was implemented in all countries allows for a direct comparison of estimated family-background effects across the European countries and with the United States.[4]

The paper is structured as follows. Section 2 introduces the database and presents the empirical model. As a general rule, the discussion in this paper will focus on student performance in math, as this is generally viewed as being most readily comparable across countries. Results on science performance are presented in appendix tables. Section 3 presents

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[2] For further evidence on positive effects of cognitive test scores on individual labor-market performance, see Neal and Johnson (1996), Currie and Thomas (2001), and the references in the latter. Also at the international level, the average performance on cognitive achievement tests has a strong and consistent influence on economic growth, and their explanatory power in growth regressions is superior to that of mere quantitative measures of education (Hanushek and Kimko 2000; Barro 2001).

[3] Cf. Wößmann (2004) for comparable European and US estimates of the "school production" part of education production functions, i.e. the effects of schools' resource endowments and institutional features of the school systems on students' educational performance.

[4] Most existing studies on education production functions are restricted to individual countries. While most US studies include some control for family background, they tend to focus on resource effects with little direct focus on family-background effects (cf. Hanushek 2002, p. 2082). Of the few studies on educational production from European countries, exceptions discussing family-background effects include Ammermüller et al. (2003), Björklund et al. (2003), Brunello and Checchi (2003), Feinstein and Symons (1999), Fertig (2003), Häkkinen et al. (2003), Lindahl (2001), and Wolter (2003).

the basic results on the impact of family background on student achievement in the 17 Western European school systems and the United States. Section 4 compares the general pattern of the evidence between Europe and the United States. Section 5 extends the analysis to quantile regressions to investigate whether there is heterogeneity in the family-background effects across the conditional achievement distribution. Section 6 discusses whether the cross-country pattern of results suggests an equity-efficiency tradeoff in educational production. Section 7 summarizes the results and concludes on directions for future research.

2. Data and Method

This section discusses the TIMSS student performance database used in this paper, reports descriptive statistics in the countries, and presents the empirical model to be estimated.

2.1. The TIMSS Student Performance Data

The Third International Mathematics and Science Study (TIMSS) is a large-scale cross-country comparative test of student achievement, conducted in 1995 by the International Association for the Evaluation of Educational Achievement (IEA), an independent international cooperative of national research institutions and government agencies.[5] From Western Europe, 17 separate school systems in 15 countries participated in TIMSS: Austria, Flemish and French Belgium, Denmark, England and Scotland, France, Germany, Greece, Iceland, Ireland, the Netherlands, Norway, Portugal, Spain, Sweden, and Switzerland.[6] The TIMSS database combines individual student-level performance data in math and science with extensive information from background questionnaires for nationally representative samples of students in each of the countries.

In TIMSS, the target population of middle school students to which each participating country administered the test was defined as those students enrolled in the two adjacent grades with the largest proportion of 13-year-olds at the time of testing.[7] Each participating

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[5] Comparable large-scale international student achievement tests are the repeat study of TIMSS in 1999, which included only five Western European countries, and the Programme for International Student Assessment (PISA), conducted in 2000 by the Organisation for Economic Co-operation and Development (OECD). The PISA target population of 15-year-old students might suffer from self-selection into the sample of students in some countries, while schooling is compulsory for the TIMSS target population of 13-year-olds in all countries considered in this paper.

[6] Thus, among the bigger Western European countries, only Finland and Italy are missing in TIMSS.

[7] In most countries, this corresponded to 7th and 8th grade of formal education (excluding pre-primary education). Exceptions are Denmark, Norway, Sweden, and the German-speaking cantons of Switzerland, where tested students had 6/7 years of formal education, as well as England and Scotland with 8/9 years (Martin and Kelly 1997).

country randomly sampled the schools to be tested in a stratified sampling design, and within each of these schools, generally one class was randomly chosen from each of the two grades and all of its students were tested in both math and science, yielding a representative sample of students within each country. As a general rule, each country was meant to sample at least 150 schools (Gonzalez and Smith 1997). Response rates were not perfect, though, while some countries sampled even more schools. As reported in Table 1, Switzerland features the largest sample size of the countries considered in this paper with 11,722 students in 613 classrooms in 327 schools, while England has the smallest number of sampled students at 3,579 and the Netherlands has the smallest number of sampled classrooms (187) and schools (95).

The TIMSS achievement tests were developed through an international consensus-building process and were endorsed by all participating countries. Given the international standardization of the test results, the cooperative nature of the test development, its endorsement by all participating countries, and the substantial efforts to ensure high-quality sampling and testing in all countries, the TIMSS student performance and background data should be comparable across countries. This should also make the empirical estimates presented in this paper directly comparable across the different countries.

The performance data are merged with background data from TIMSS background questionnaires for each individual student. The information on student- and family-background characteristics are mainly drawn from student background questionnaires, where students report the level of their parents' education, the number of books in their home, whether they live with both parents and were born in the country, and their sex and age. Additionally, school-principal background questionnaires provide information on the community location of the school. Except for student age, all background data are used as dummy variables in this paper.

Complete performance data are available for all the students participating in TIMSS. In terms of the background data, England did not administer the question on parental education in an internationally comparable way, and France on students' country of birth. Furthermore, some students and school principals failed to answer some items in the background questionnaires. While in general, response rates are reasonable, in some countries data on parental education and community location are missing for more than 40 percent of the students (cf. Table A1 in the appendix). In cases of missing data, the values were imputed within each country for the analyses in this paper. This seems superior to dropping all students with missing data on some explanatory variables altogether, because the latter would

disregard the information available for these students on other explanatory variables, would severely reduce the sample size in several countries, and would probably introduce bias because it seems likely that observations are not missing at random. Appendix 1 presents the details of the method used to impute missing data, which uses both median imputation and imputation based on probit models relating the observations from students with original data to a set of "fundamental" explanatory variables available for all students.

2.2. Cross-Country Comparative Descriptive Statistics

TIMSS measured student performance separately in math and science, using an international achievement scale with scores having an international mean of 500 and an international standard deviation of 100. As shown in Table 1, the mean math performance in TIMSS of the Western European countries ranges from 438.3 in Portugal to 561.7 in Flemish Belgium. As a comparison, Singapore was the international top performer at 622.3, South Africa was the lowest performer at 351, and the United States scored an average of 487.8 test-score points in math. Portugal has the lowest variation in math performance among its students, both when measured by the absolute standard deviation in test scores (63.7) and relative to its mean performance (14.5). On the relative measure, Flemish Belgium and France also feature relatively low performance variations. At the other extreme, England has the highest standard deviation in absolute terms (92.7), while in relative terms it is Greece (19.4). The United States also shows a relatively large performance variation among its students.

Table 2 presents country means of the data on family background used in this paper. The average parental education varies widely among the countries. On the one extreme, 57% of Portuguese parents do not have any secondary education. On the other extreme, 40% of parents in French Belgium have a finished university education. Some of the cross-country variation in parental education levels may reflect differences in the education systems, though. The number of books in the students' home may be a proxy for the educational background of the family that is more readily comparable across countries. Portugal again fares relatively low on this measure, while Norway features relatively high values. The distribution across the five categories of books at home in countries such as England, Germany, and the United States is actually very close together.

Across Europe, the Netherlands had the lowest share of students not living with both parents at 9%, while Scotland had the highest share at 19%. The share was even higher in the United States at 21%. The share of immigrant students ranges from 3% in Flemish Belgium, Ireland, and Spain to 12% in Switzerland. In all countries, students are roughly equally

divided into boys and girls. The average age of the tested students ranges from 13.1 years in Greece and Iceland to 14.3 years in Germany. In all countries, the student population is roughly equally divided between the two tested grades. Sweden and Switzerland tested students in a third grade above the other two, with roughly one third of their samples coming from each grade. In terms of the community in which the schools are located, Norway features a relatively high share of geographically isolated locations (12%) and a relatively low share of schools located close to the center of a town (also 12%). By contrast, several countries do not feature tested school in isolated areas, and 62% of Portuguese students visit a school close to a town center.

2.3. The Empirical Model

To quantify the extent of equality of educational opportunities for children from different backgrounds, the size of the influence of students' family background on their educational performance is estimated for each country in the following form:

$$T_{ics} = F_{ics}\alpha_1 + D_{ics}^F\delta_1 + \left(D_{ics}^F F_{ics}\right)\delta_2 + \varepsilon_{ics} \ , \tag{1}$$

where T is the test score of student i in class c in school s and F is a vector of family-background variables. The coefficient vectors α_1, δ_1, and δ_2 are to be estimated. The inclusion of the imputation controls D^F and the structure of the error term ε are discussed below.

Family background such as parental education is exogenous to student performance. Furthermore, there is no self-selection into the sample because 7th- and 8th-grade schooling is compulsory in Western Europe and the United States. Consequently, least-squares estimates of α_1 should represent causal family-background effects. The estimation intentionally does not control for school characteristics, such as schools' resource endowments or institutional features, as in standard education production functions, because the paper is interested in the total impact of family background on student performance, including any effect that might work through families' differential access to schools or their influence on school policies.

It helps to clarify what the estimates of the coefficients α_1 on the family-background variables, and especially differences in the estimates across countries, mean and do not mean. Because the TIMSS data were generated by the same data-generating process in the different countries and are therefore directly comparable across countries, and given the technical constraints on the pedagogical process, the prior should be that the size of the *effect* of any family-background characteristic on students' educational performance should be the same

everywhere. If this is not the case, this implies that there must be differences in how the school systems work. This does *not* reflect different *distributions* of family-background characteristics in the different populations, as evident in Table 2, which are no a priori reason for the performance gap between students with two different characteristics to differ.

As discussed in the previous section, some of the data are imputed rather than original. Generally, data imputation introduces measurement error in the explanatory variables, which should make it more difficult to observe statistically significant effects. Still, to make sure that the results are not driven by imputed data, a vector of dummy variables D^F is included as controls in the estimation. The vector D^F contains one dummy for each variable in the family-background vector F that takes the value of 1 for observations with missing and thus imputed data and 0 for observations with original data. The inclusion of D^F as controls in the estimation allows the observations with missing data on each variable to have their own intercepts. The inclusion of the interaction term between imputation dummies and background data, $D^F F$, allows them to also have their own slopes for the respective variable. These imputation controls for every variable with missing values ensure that the results are robust against possible bias arising from data imputation.

Further problems in the econometric estimation of equation (1) are that the explanatory variables in this study are measured at different levels, with some of them not varying within classes or schools; that the performance of students within the same school may not be independent from one another; and that the primary sampling unit (PSU) of the two-stage clustered sampling design in TIMSS was the school, not the individual student (see Section 2.1). As shown by Moulton (1986), a hierarchical structure of the data requires the addition of higher-level error components to avoid spurious results. Therefore, the error term ε of equation (1) has a school-level and a class-level element in addition to the individual-student element:

$$\varepsilon_{ics} = \eta_s + \nu_c + \upsilon_i \quad ,$$

(2)

where η is a school-specific error component, ν is a class-specific error component, and υ is a student-specific error component. Clustering-robust linear regression (CRLR) is used to estimate standard errors that recognize this clustering of the survey design. The CRLR method relaxes the independence assumption and requires only that the observations be independent across the PSUs, i.e. across schools. By allowing any given amount of correlation within the PSUs, CRLR estimates appropriate standard errors when many

observations share the same value on some but not all independent variables (cf. Deaton 1997).

Finally, TIMSS used a stratified sampling design within each country, producing varying sampling probabilities for different students (Martin and Kelly 1997). To obtain nationally representative coefficient estimates from the stratified survey data, weighted least squares (WLS) estimation using the sampling probabilities as weights is employed. The WLS estimation ensures that the proportional contribution to the parameter estimates of each stratum in the sample is the same as would have been obtained in a complete census enumeration (DuMouchel and Duncan 1983; Wooldridge 2001).

3. Results for Individual Countries

This section presents results on the effect of several family-background features on students' educational performance in the United States and 17 Western European education systems. The size of the family-background effects can be viewed as a measure of the equality of educational opportunities for children from different backgrounds. The results, reported in Table 3, start with several measures of the educational background of the family, followed by student characteristics and the community location. Here as well as in the remaining sections, the discussion will focus on results for math performance. Results for science performance are relegated to Tables A2-A3 in the appendix.

3.1. Families' Educational and Socio-Economic Background

The education level attained by the parents is strongly related to student performance in all European countries, as well as the United States. The specification does not make the assumption of a linear relationship, e.g. by using parents' years of education as a single explanatory measure. Rather, the estimations use all the information available in the background questionnaires and allow a more flexible functional form by including a dummy for each category, namely parents whose highest education level is some secondary, finished secondary, some after secondary, and finished university, with parents with no secondary education at all as the residual category.

Across the European countries, the relationship between parents' education and their children's math performance is particularly low in French Belgium, the only country where the difference in math performance between students whose parents finished university and students whose parents had no secondary education is not statistically significant (although it

is in science, cf. Table A2). At the other extreme, this difference is largest in Greece at 51.3 test-score points. The effect size is smaller in all Western European countries than the one observed in the United States (52.7), where basically all previous studies found important family-background effects (cf. Hanushek 2002). Effect sizes of 40-50 test-score points, as observed in of the countries, are very large indeed: They are of the same order of magnitude as the performance difference between 7th and 8th graders in most countries, and equal about half a standard deviation in TIMSS test scores (cf. Table 1). When considering the performance difference between children of parents who finished university and children of parents who finished secondary education, there is basically no difference in Spain, and the largest difference is observed in Scotland at 39.7 test-score points.

A limitation to the comparability of the effects of parental education across countries is that the categories in the different countries may not be easily comparable. Therefore, the second indicator of family background, the number of books in the students' home, may be particularly interesting for cross-country comparisons. Students were asked to report the total number of books that are in their home, not counting newspapers, magazines, or their school books. This measure can be viewed as a proxy of the educational, social, and economic background of the students' families that is readily comparable across countries. Again, this measure was collected in five categories. In the regressions reported in Table 3, England appears to feature the largest effect based on this measure. However, England is also the only country without data on parental education, which might affect the estimates on books at home. Therefore, the regressions were re-estimated without controlling for the parental education data also for all other countries to see whether the relative size of the coefficient on books at home in England can be attributed to the missing parental-education data. The coefficients on books at home actually do increase in all other countries once parental education is excluded.

However, England still has the largest effect among all countries, with students from homes with more than two bookcases full of books performing 104.4 math test-score points better than students from homes with less than one shelf of books. Scotland (93.6) and Germany (84.9) also feature very large family-background effects on this account, followed by Austria, Ireland, and Sweden. In all these countries, the effect of family background as measured by the number of books in a student's home on student performance is comparable to or larger than the effect found in the United States. At the other extreme, France features the lowest effect (20.9), and Flemish Belgium has the lowest effects when looked at relative

to one shelf of books as the lowest category. A third country with relatively small effects is Portugal. This general pattern of results is basically unaffected by which specific difference one looks at; e.g. it also holds for two bookcases relative to less than one shelf, more than two bookcases relative to one shelf, more than two bookcases relative to one bookcase, or two bookcases relative to one shelf.

The relatively low intergenerational *educational* mobility in Britain mirrors previous findings of relatively low intergenerational *earnings* mobility in this country (cf. Dearden et al. 1997; Solon 2002). However, the Swedish results contrast with studies finding relatively high intergenerational earnings mobility in Sweden (cf. Björklund and Jäntti 1997; Solon 2002), suggesting that the latter is not predominantly driven by particularly strong equality in educational opportunities.

Two neighboring countries of which one belongs to the group of countries with small family-background impacts and the other to the group with large family-background impacts are France and Germany. In a French-German comparison of the impact of family background on educational attainment, Lauer (2003) hypothesizes that family background should have a larger impact on children's educational prospects in Germany than in France, mainly based on the observation that streaming takes place much earlier in the German school system than in the French one. However, her evidence suggests that the two countries prove surprisingly similar with regard to the impact of family background on educational attainment, i.e. on a measure of educational *quantity*. By contrast, my results show that when using a measure of educational *quality* instead, her hypothesis actually holds true. That is, the larger family-background effect in Germany materializes in terms of better educational performance of the children rather than higher educational attainment. One way to reconcile the two findings would be that certification regimes differ, so that the attainment certificates represent different ranges of actual skills in the two countries. The extent to which the differing finding with regard to performance is due to the different streaming practices in the two systems is an open question, though, because the two systems also differ in several other important dimensions. Most notably, France features a much more widespread prevalence of pre-primary education than Germany. Starting at the age of 3, more than 90% of children are enrolled in the French education system, while in Germany, this is not the case until the age of 7 (data for 1996 from OECD 1998). Of the children aged 2-4, 80% are enrolled in France but only 45% in Germany. This may be another impact factor lying behind the large French-German difference in family-background effects, and it could also account for the low family-

background effect in Flemish Belgium where the 90% enrollment range also starts at the age of 3 and where 79% of children aged 2-4 are enrolled.

In interpreting the results, one has to bear in mind that family-background measures such as parental education or the number of books at home will be correlated with other, unobserved aspects of family background, such as parents' motivation or their willingness and capability to help with homework. Therefore, the estimated coefficients have to be interpreted as the effect of the respective variable and anything else that goes with it. In that sense, both parental education and the number of books at home serve as general proxies for the educational, social and economic background in the students' homes.[8]

3.2. *Single Parents, Immigrants, Other Student Characteristics, and Community Location*

The next measure of family background is whether students live with both parents. In no country do students living with both parents perform statistically significantly worse than students not living with both parents, and they perform statistically significantly better in the United States and 8 European school systems. Only in Norway (18.7) is the effect larger than in the United States (15.5), and the next-largest effects are in Ireland, Greece, and Germany.

The other considered student characteristics are also significantly related to student performance in many of the countries. Native students perform statistically significantly better than immigrated students in 10 European countries, but not in the United States (at least in math). The estimated effect is largest in Sweden (30.3), followed by Austria (25.9), Switzerland, Norway, and Denmark. By contrast, immigrated students actually perform statistically significantly (at least at the 5% level) better than native students in Ireland (13.2) and Portugal (6.1).[9]

With regard to students' gender, Flemish Belgium, Iceland, and Sweden are the only countries where girls do not perform statistically significantly worse in math than boys. The boys' lead is largest by far in Ireland (19.7), followed by Switzerland (13.3), French Belgium (13.1), and Denmark (12.6).

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[8] The estimates may also to some extent reflect heritable ability. More able parents, who obtained more education, may have more able children, who then perform better on the performance tests. Behrman and Rosenzweig (2002) show for Minnesota twins that heritable ability is a likely source of the correlation between the quantitative educational attainment of mothers and their children. This is not found for fathers, though, and Behrman et al. (1999) find a causal impact of mothers' schooling on their children's schooling, working through home teaching, in rural India during the green revolution. The extent to which heritability can account for the cross-country variation in the presented findings should be limited.

[9] Because the strong correlation between the immigration status of parents and children regularly causes problems of multicollinearity, only the latter was included in the regressions and the former left out, with the evident ensuing consequences for the interpretation of results.

Controlling for grade differences, older students perform statistically significantly worse in most countries, which presumably reflects a grade repetition effect. In all countries, 8th-graders perform statistically significantly higher than 7th-graders. The performance difference ranges from 23.0 in England to 67.4 in France. In countries with small performance differences between grades (e.g., England, Iceland, Scotland, and to a lesser extent Norway and Sweden), the age effect tends to be low (in absolute terms), while it tends to be high in countries with strongly negative age effects (e.g., France, the Netherlands, and the two Belgian systems). This may reflect differences in the policies of how to deal with low-performing students. In the latter countries, the lowest-performing students regularly seem to be relegated into lower grades, so that the grade difference is relatively large, and at the same time the age effect is strongly negative since the relegated students are older but relatively low performing. By contrast, in the former countries, low-performing students generally seem not to be relegated to lower grades, so that the performance difference between grades is relatively low as the low-performers remain in upper grade, and age does not make much of a difference within grades and might even have a slightly positive effect on performance.

Finally, there is no clear pattern in the relative performance of schools by community location. In some countries, schools in geographically isolated locations perform much worse, while in others, they perform much better. Here, it should also be noted that most of the statistically significant estimates are based on very few observations, because only 2 schools in Austria and Portugal, and only 1 in Spain, are reported to be geographically isolated (cf. Table 2). There is also no clear pattern of results for schools located in communities close to the center of a town.

The explanatory power of the student and family background characteristics, when measured as the proportion of the test-score variation accounted for by the model (the R^2), is largest in Switzerland at 26.4% (disregarding the part "explained" by imputation controls), followed by French Belgium, Sweden, and France. At the lower end, only 9.2% of the performance variation can be attributed to family background in Iceland, followed by Denmark, Norway, and Flemish Belgium. In the United States, it is 17.5%.

4. Equality of Educational Opportunity in Europe vs. the United States: The Aggregate Picture

The previous discussion already allowed a comparison of results for European countries with the United States at an individual-country level. To estimate more formally how the equality

of educational opportunity compares between the United States and Europe as an aggregate, Table 4 reports the same model specification used above in Table 3 for the pooled sample of all students from the European countries and the United States. For each explanatory variable, the pooled regression includes an interaction term with a Europe dummy to test whether the family-background effect differs between Europe and the United States. The regression also controls for a whole set of country dummies to account for country fixed effects.

Comparing Europe as an aggregate to the United States, there is remarkably little difference in the direction, size, and significance of the family-background effects. Particularly when considering parental education and books at home as the main measures of family background, their effects on student performance in math actually barely differ between the "average" European country and the United States. At low levels of significance, there are slight differences in the size of the performance difference between the lowest two categories, and the effect of parents having finished university is somewhat larger in the United States. As a general pattern, however, family background has a strong and comparable impact on student performance both in Europe and the United States.

The effect of students living with both parents is statistically significantly smaller in Europe than in the United States, but it is still statistically significantly positive. Europe differs from the United States in that immigrant students perform statistically significantly worse than native students in math, which is not the case in the United States. There is also a difference in that students from schools located in geographically isolated areas perform statistically significantly worse in the United States, but not in Europe. However, the effects of students' age, gender, grade, and town-center location of schools do not differ significantly between Europe and the United States. All in all, when taking Western Europe as a whole, there is remarkably little difference in family-background effects to the United States, not even in their size.

5. Heterogeneity of Family-Background Effects by Ability

Given that 75-90% of the test-score variation in the different countries remains unexplained, a large part of the performance variation across students has to be attributed to omitted variables (in addition to measurement errors). This is not unexpected, because the basic learning ability of students – e.g., their innate ability or their learning motivation – remains unobserved and thus enters the error term ε of equation (1) (or, more precisely, the student-specific error component υ in equation (2)). However, it begs the question whether the

family-background effects vary across the ability distribution of students. E.g., it may be of different importance to low-ability students compared to high-ability students whether they come from a disadvantaged family background. Such heterogeneity in the family-background effects can be detected by quantile regressions (cf. Koenker and Bassett 1978).

Student ability itself remains unmeasured, virtually by definition. However, once family-background effects are controlled for, the conditional performance distribution should be strongly correlated with ability (or, more precisely, with that part of ability that is not correlated with family background). In the following, this conditional performance distribution is termed "ability." Quantile regressions estimate the effect of family background on student performance for students at different points on this ability distribution. While Eide and Showalter (1998) and Levin (2001) have applied the quantile regression method to the estimation of resource effects in education, Fertig (2003) seems to be the only country study that uses quantile regressions to estimate family-background effects. However, the distinction between family background and underlying ability seems to offer a particularly appealing analytical background for the estimation and interpretation of quantile estimates. The family-background proxy used in this section is the number of books at home, which has the advantage over parental education to be readily comparable across countries and whose effect is considerably stronger than that of any other variable.

The horizontal lines of Figure 1 replicate the least-squares coefficients on the four books-at-home dummies from Table 3 for each country. The relatively large effects in England and the relatively small effects in France are immediately apparent. The curved lines with dots report quantile-regression coefficients of the same model for 19 quantiles ranging from 0.05 to 0.95.[10] As a general pattern, these quantile-regression estimates are relatively constant across quantiles in almost all countries. This remarkable uniformity suggests that the family-background effects do *not* vary strongly with the underlying ability of students.

To the extent that they do, they tend to *increase* with quantiles in the vast majority of countries. This pattern of family-background effects slightly increasing with ability is particularly notable in Austria, England, Ireland, Norway, Spain, Sweden, and the United States. To a lesser extent, it may also be observed in French Belgium, France, Germany, Greece, Iceland, Portugal, Scotland, and Switzerland. However, England is the only country

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[10] Confidence intervals are not shown for expositional reasons. For the least-squares estimates, standard errors are reported in Table 3. The precision of the quantile-regression coefficients is roughly comparable in size.

where a really strong pattern of effect heterogeneity exists.[11] In all these countries – albeit to varying degrees – a good family background is most important for high-ability children. Thus, for instance, while the performance lead of students from homes with more than two bookcases over students from homes with less than one shelf of books is 69.4 for students at the 10th percentile of the conditional performance distribution in England, it is 146.5 for students at the 90th percentile. This effect difference of 77.1 between the 10th and the 90th percentile in England compares, e.g., to a difference of only 5.3 in Switzerland (59.1 at the 90th percentile versus 53.7 at the 10th percentile). In the countries where no increasing pattern can be observed, the family-background effect seems to slightly shrink with ability in the Netherlands, make roughly a U-shape in Flemish Belgium, and an inverted-U-shape in Denmark.[12]

6. Is There a Tradeoff Between Equality and Efficiency?

Viewing the size of the family-background effects as a measure of the equality of educational opportunities for children from different backgrounds, the French school system seems to achieve the highest extent of equal opportunity, and the British systems the lowest. From a policy viewpoint, this begs the question whether equalizing educational opportunities must be bought by having to accept a lower overall level of performance, i.e. whether a tradeoff exists between educational equity and efficiency.

To give a cross-country view on this question, Figure 2 plots the mean of the math achievement in each country against a measure of the family-background effect in the country, namely the performance difference between students with more than two bookcases at home and students with less than one shelf of books at home. From this scatter plot, it is immediately evident that there is no direct relationship between average performance and our measure of equality of opportunity across countries. The cross-country correlation coefficient between the two measures is 0.002.

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[11] One might advance the thought that the conditional performance may reflect other, unmeasured family-background characteristics as much as underlying ability. At a first glance, this would suit to the fact that England is the only country with a strong positive link between family-background effects and underlying ability and that it is also the only country with no data available to control for parental education as a second family-background measure. However, performing the same quantile regressions under negligence of the parental education variables for the other countries reveals that this is not driving the exceptional English result.

[12] The median regression can also be viewed as a test of the least-squares result for robustness against outliers. As is evident from Figure 1, in most countries the least-squares and the median estimates do roughly coincide, showing robustness of the least-squares results to outlying observations.

When using other proxies for family-background effects, the correlation with mean performance is similarly low, and often negative. For example, the correlation coefficient is –0.03 for the performance difference between students with more than two bookcases relative to students with one shelf as the proxy for family-background effects, –0.15 for more than two bookcases relative to one bookcase, and 0.11 for two bookcases relative to less than one shelf as well as one shelf. Likewise, using parental education as the family-background proxy, the correlation coefficient with mean math performance is –0.11 when considering the performance difference between students whose parents finished university relative to students whose parents had no secondary education, and –0.10 when considering finished university relative to finished secondary. Thus, the cross-country pattern of mean performance and family-background effects in Europe suggests that there is no apparent tradeoff between achieving efficiency in educational production and equality of educational opportunity.

7. Summary and Conclusions

This paper has presented consistent and comparable evidence on how equal educational opportunities are for children from different family backgrounds in Western European countries and the United States. The evidence is based on the estimated size of the impact that several measures of family background have on students' achievement on the TIMSS international math and science test. In all countries, the impact of family background on students' cognitive skills is strong. For example, the performance difference between children of parents with the lowest and the highest educational category easily surmount a whole grade equivalent in many countries. Furthermore, the model analyzed in this paper is able to account for at least 9% of the total test-score variation (in Iceland), and up to 26.4% (in Switzerland). Both the size of the individual effects and the explained proportion of the test-score variation dwarf the effects that have been found for school inputs such as class sizes, resource endowments, and institutional features for the same countries and performance data (Wößmann 2004).

With regard to the general pattern of strong family-background effects, and even with regard to the particular size of most family-background effects, educational production in Western Europe (as an aggregate) seems remarkably similar to educational production in the United States. Still, there are also noteworthy variations across European countries. Using the number of books in the students' home as a proxy for the educational and socio-economic

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background of the family, France and Flemish Belgium achieve the most equitable performance for students from different backgrounds, and Britain and Germany the least. In most countries, the family-background effect does not vary strongly for students of different underlying ability. If anything, the effects tend to be stronger for higher-ability children in some countries, most notably in England. Across countries, the size of the family-background effects is basically unrelated to mean performance, suggesting that there is no inevitable equity-efficiency tradeoff in educational production. More equal opportunities for students from different family backgrounds thus do not necessarily have to be bought by lower average performance.

The findings in this paper open the door for much more in-depth future research. For example, the paper did not look into how family background effects work through different channels – through peer formation, differential access to resources, or other impact on school policies. Likewise, there might be important interactions between the family-background effects themselves, for example between parental education and immigration status. While this paper has focused mainly on basic cognitive skills in math as an educational output, only briefly reporting results in science, there are many other outcomes of the educational process that should be considered in the future, such as social capabilities and motivation.

The results of this paper are generally in line with the broad pattern of the existing cross-country evidence on intergenerational earnings mobility, which found that the United States and the United Kingdom appear to be relatively immobile societies (Solon 2002). The evidence on intergenerational educational mobility presented here extends this pattern to a much wider range of countries. The understanding of how educational and earnings mobility relate and how the one transforms into the other might be greatly advanced if family-background and student achievement data could be directly linked to data on labor-market outcomes in different generations.

The most auspicious and proximate road for future research, however, seems to be to look at what might lie behind the cross-country differences in the extent of equality of educational opportunities estimated in this paper. The results can feed future work trying to explain why some countries achieve more educational equality than others, by relating the estimated family-background effects to characteristic features of the school systems and societal institutions across countries. Such research might advance our understanding of how more equal educational opportunities may be achieved.

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Table 1: Student Performance and Sample Size

Student performance: International test scores. Standard deviation in parentheses.
Standard deviation in percent of country mean test score in brackets. – Sample size: Absolute numbers.

	AUS	BFL	BFR	DEN	ENG	FRA	GER	GRE	ICE
Student performance									
Math score	524.1	561.7	517.5	485.3	491.3	514.4	496.6	461.2	473.1
Standard deviation	*(89.9)*	*(85.3)*	*(83.1)*	*(83.1)*	*(92.7)*	*(78.3)*	*(88.2)*	*(89.6)*	*(73.3)*
Std. dev./score (in percent)	*[17.2]*	*[15.2]*	*[16.1]*	*[17.1]*	*[18.9]*	*[15.2]*	*[17.8]*	*[19.4]*	*[15.5]*
Science score	537.9	540.3	457.5	460.5	532.5	473.9	515.2	472.2	477.8
Standard deviation	*(98.0)*	*(78.3)*	*(83.7)*	*(89.4)*	*(105.5)*	*(78.9)*	*(99.8)*	*(89.6)*	*(78.7)*
Std. dev./score (in percent)	*[18.2]*	*[14.5]*	*[18.3]*	*[19.4]*	*[19.8]*	*[16.7]*	*[19.4]*	*[19.0]*	*[16.5]*
Sample size									
Students	5,786	5,662	4,883	4,370	3,579	6,014	5,763	7,921	3,730
Classes	249	296	261	282	243	253	272	312	274
Schools	129	141	120	153	127	134	137	156	155

Table 1 (continued)

	IRE	NET	NOR	POR	SCO	SPA	SWE	SWI	USA
Student performance									
Math score	513.5	529.0	481.8	438.3	481.1	467.6	517.1	544.6	487.8
Standard deviation	*(90.8)*	*(85.2)*	*(82.8)*	*(63.7)*	*(86.5)*	*(74.2)*	*(90.2)*	*(91.2)*	*(90.9)*
Std. dev./score (in percent)	*[17.7]*	*[16.1]*	*[17.2]*	*[14.5]*	*[18.0]*	*[15.9]*	*[17.5]*	*[16.8]*	*[18.6]*
Science score	516.4	539.6	505.0	452.9	493.2	497.1	532.0	521.0	521.4
Standard deviation	*(95.7)*	*(85.0)*	*(88.9)*	*(77.1)*	*(99.9)*	*(81.4)*	*(95.7)*	*(93.9)*	*(106.2)*
Std. dev./score (in percent)	*[18.5]*	*[15.7]*	*[17.6]*	*[17.0]*	*[20.3]*	*[16.4]*	*[18.0]*	*[18.0]*	*[20.4]*
Sample size									
Students	6,203	4,084	5,736	6,753	5,776	7,596	8,855	11,722	10,973
Classes	261	187	287	283	257	309	535	613	529
Schools	132	95	249	142	128	154	270	327	183

Table 2: Descriptive Family-Background Statistics

Country means. Standard deviations in parentheses for continuous variable (the std. dev. for dummies simply equals roughly 2*mean*(1–mean), neglecting the weighting). Only non-imputed data for each variable. Weighted by sampling probabilities.

	AUS	BFL	BFR	DEN	ENG	FRA	GER	GRE	ICE
Parents' education									
Primary	–	0.08	0.06	–	–	0.09	–	0.23	0.08
Some secondary	0.10	0.18	0.09	0.11	–	0.25	0.47	0.18	0.09
Finished secondary	0.78	0.40	0.20	0.35	–	0.33	0.34	0.17	0.12
Some after secondary	–	0.06	0.25	0.33	–	0.15	0.06	0.22	0.39
Finished university	0.13	0.29	0.40	0.21	–	0.18	0.14	0.20	0.32
Books at home									
Less than one shelf (<=10)	0.11	0.09	0.06	0.03	0.06	0.05	0.08	0.05	0.01
One shelf (11-25)	0.16	0.16	0.10	0.09	0.13	0.19	0.14	0.23	0.05
One bookcase (26-100)	0.32	0.34	0.29	0.29	0.27	0.36	0.28	0.41	0.30
Two bookcases (101-200)	0.18	0.19	0.21	0.23	0.23	0.20	0.19	0.19	0.28
More than two bookcases (>200)	0.24	0.22	0.35	0.36	0.32	0.20	0.32	0.12	0.36
Living with both parents	0.85	0.90	0.85	0.86	0.83	0.86	0.83	0.84	0.84
Born in country	0.94	0.97	0.91	0.94	0.95	–	0.90	0.94	0.93
Sex (female)	0.52	0.50	0.52	0.51	0.47	0.50	0.51	0.48	0.49
Age	13.81	13.64	13.79	13.43	13.57	13.81	14.27	13.12	13.14
	(0.71)	(0.76)	(0.91)	(0.64)	(0.58)	(0.91)	(0.82)	(0.74)	(0.58)
Upper grade	0.49	0.54	0.54	0.55	0.51	0.49	0.49	0.48	0.50
Above upper grade	–	–	–	–	–	–	–	–	–
Community location									
Geographically isolated	0.00	0.00	0.00	0.07	0.04	0.00	0.02	0.03	0.07
Close to town center	0.43	0.39	0.56	0.23	0.33	0.39	0.48	0.52	0.42

Table 2 (continued)

	IRE	NET	NOR	POR	SCO	SPA	SWE	SWI	USA
Parents' education									
Primary	0.07	0.04	–	0.57	–	0.43	–	–	0.02
Some secondary	0.21	0.09	0.12	0.21	0.23	0.16	0.14	0.15	0.06
Finished secondary	0.30	0.31	0.12	0.09	0.36	0.10	0.44	0.61	0.19
Some after secondary	0.23	0.39	0.40	0.05	0.18	0.12	0.10	0.11	0.38
Finished university	0.19	0.18	0.36	0.09	0.23	0.19	0.32	0.13	0.36
Books at home									
Less than one shelf (<=10)	0.07	0.07	0.02	0.12	0.11	0.05	0.03	0.07	0.08
One shelf (11-25)	0.16	0.15	0.06	0.27	0.17	0.18	0.08	0.15	0.12
One bookcase (26-100)	0.34	0.34	0.25	0.31	0.29	0.33	0.24	0.31	0.28
Two bookcases (101-200)	0.21	0.20	0.23	0.13	0.19	0.19	0.24	0.21	0.21
More than two bookcases (>200)	0.22	0.24	0.44	0.17	0.25	0.25	0.41	0.27	0.31
Living with both parents	0.90	0.91	0.85	0.88	0.81	0.89	0.86	0.84	0.79
Born in country	0.97	0.95	0.95	0.92	0.92	0.97	0.92	0.88	0.93
Sex (female)	0.52	0.50	0.50	0.50	0.49	0.50	0.49	0.50	0.50
Age	13.93	13.82	13.37	13.97	13.22	13.76	13.94	14.07	13.74
	(0.70)	(0.80)	(0.60)	(1.11)	(0.60)	(0.86)	(0.88)	(1.01)	(0.72)
Upper grade	0.50	0.52	0.50	0.48	0.50	0.50	0.33	0.36	0.50
Above upper grade	–	–	–	–	–	–	0.34	0.29	–
Community location									
Geographically isolated	0.06	0.00	0.12	0.01	0.05	0.01	0.04	0.04	0.03
Close to town center	0.35	0.22	0.12	0.62	0.44	0.23	0.46	0.23	0.44

Table 3: Family Background and Student Performance

Least-squares regression within each country, weighted by students' sampling probabilities.
Dependent variable: TIMSS math test score. Clustering-robust standard errors in parentheses.

	AUS	BFL	BFR	DEN	ENG	FRA	GER	GRE	ICE
Parents' education									
Some secondary	–	6.98	-19.79$^+$	–	–	8.38	–	9.24*	25.83*
		(12.03)	(9.40)			(6.64)		(3.48)	(7.82)
Finished secondary	16.64$^+$	20.37$^°$	-11.04	14.71$^°$	–	19.63*	12.42*	23.00*	30.75*
	(6.45)	(11.08)	(9.32)	(7.53)		(6.88)	(3.44)	(3.44)	(8.14)
Some after secondary	–	37.87*	2.02	24.97*	–	21.24*	11.37$^°$	23.01*	34.81*
		(13.27)	(10.15)	(7.60)		(7.16)	(6.26)	(5.19)	(6.89)
Finished university	31.62*	41.39*	9.13	32.54*	–	38.25*	29.51*	51.28*	43.36*
	(8.27)	(12.18)	(9.71)	(7.39)		(6.94)	(5.25)	(4.44)	(7.19)
Books at home									
One shelf (11-25)	18.22*	15.86*	9.66	14.74$^°$	24.41*	-4.62	20.06*	11.15*	19.23
	(4.26)	(5.51)	(6.96)	(8.02)	(5.96)	(4.98)	(4.28)	(3.85)	(11.90)
One bookcase (26-100)	37.70*	26.56*	29.53*	33.08*	60.29*	8.75$^°$	42.78*	34.16*	30.46*
	(4.67)	(6.20)	(5.00)	(7.73)	(6.45)	(4.67)	(4.79)	(4.58)	(10.43)
Two bookcases (101-200)	62.83*	33.74*	36.69*	45.48*	81.22*	16.63*	65.12*	44.70*	44.44*
	(5.91)	(6.19)	(5.25)	(8.12)	(6.62)	(4.93)	(5.86)	(5.76)	(10.47)
More than two bookcases (>200)	71.83*	29.97*	44.68*	53.45*	104.43*	11.17$^+$	75.24*	44.66*	54.54*
	(5.25)	(6.45)	(5.45)	(7.63)	(7.77)	(5.23)	(5.34)	(5.64)	(11.39)
Living with both parents	-2.84	-2.28	-6.97	2.46	4.51	7.82*	9.37*	13.85*	5.37
	(2.99)	(4.56)	(4.36)	(3.82)	(4.27)	(2.46)	(3.10)	(2.46)	(3.98)
Born in country	25.93*	8.54	18.96*	20.40*	10.59	–	16.07*	9.47$^+$	10.32$^+$
	(6.79)	(8.28)	(5.61)	(6.29)	(7.42)		(4.89)	(4.47)	(5.22)
Female	-10.22*	0.34	-13.05*	-12.56*	-9.13$^°$	-10.69*	-8.51*	-9.73*	-3.21
	(2.95)	(6.42)	(3.42)	(2.60)	(4.87)	(2.04)	(3.28)	(1.92)	(2.83)
Age	-22.79*	-36.08*	-31.36*	-19.39*	7.03	-24.74*	-18.67*	-13.42*	-0.70
	(2.68)	(3.05)	(1.97)	(3.37)	(4.99)	(2.36)	(2.50)	(3.34)	(4.48)
Upper grade	52.27*	52.46*	55.82*	57.79*	23.00*	67.39*	42.31*	55.59*	26.80*
	(3.73)	(5.14)	(3.92)	(4.68)	(5.30)	(4.36)	(3.78)	(4.62)	(7.57)
Above upper grade	–	–	–	–	–	–	–	–	–
Community location									
Geographically isolated	50.49*	–	–	-26.10$^+$	-11.25	–	27.11	-7.39	-9.71
	(10.42)			(10.19)	(11.42)		(31.11)	(5.61)	(5.99)
Close to town center	15.70$^+$	-4.48	12.82$^+$	-12.55$^+$	-12.30	2.25	4.65	15.28*	2.24
	(7.13)	(8.53)	(6.38)	(6.11)	(8.51)	(5.23)	(9.81)	(5.17)	(4.77)
Imputation controls	yes	yes	yes	yes	yes	yes	yes	yes	yes
Students [Unit of observation]	5786	5662	4883	4370	3579	6014	5763	7921	3730
Schools [Unit of clustering]	129	141	120	153	127	134	137	156	155
R^2	0.187	0.149	0.243	0.142	0.157	0.230	0.218	0.201	0.118
R^2 (without imputation controls)	0.173	0.137	0.221	0.123	0.148	0.211	0.187	0.179	0.092

Significance levels (based on clustering-robust standard errors): * 1%. – $^+$ 5%. – $^°$ 10%.

Table 3 (continued)

	IRE	NET	NOR	POR	SCO	SPA	SWE	SWI	USA
Parents' education									
Some secondary	7.65	25.63$^+$	–	5.36$^+$	–	7.82*	–	–	11.06
	(5.27)	(10.05)		(2.19)		(2.57)			(8.63)
Finished secondary	15.60*	24.46$^+$	4.62	13.92*	-1.58	22.19*	13.63*	16.01*	17.20°
	(5.49)	(10.43)	(9.10)	(3.32)	(4.46)	(2.99)	(4.18)	(3.66)	(8.83)
Some after secondary	25.20*	44.27*	20.28$^+$	24.64*	14.36*	8.90*	22.42*	24.41*	31.48*
	(5.60)	(9.44)	(8.20)	(4.15)	(5.33)	(3.19)	(5.00)	(4.71)	(8.29)
Finished university	36.57*	40.71*	27.46*	37.52*	38.07*	19.78*	29.54*	34.98*	52.66*
	(6.40)	(10.50)	(7.88)	(3.87)	(5.09)	(3.67)	(4.70)	(4.95)	(9.16)
Books at home									
One shelf (11-25)	13.99*	17.34$^+$	10.20	8.81*	26.02*	15.33*	3.66	18.97*	9.75$^+$
	(4.89)	(7.49)	(9.58)	(2.22)	(3.76)	(4.48)	(5.55)	(4.48)	(3.78)
One bookcase (26-100)	47.36*	37.53*	23.33*	17.93*	48.05*	31.12*	36.84*	39.69*	34.57*
	(5.06)	(6.77)	(8.81)	(2.55)	(3.87)	(4.28)	(4.99)	(4.66)	(3.56)
Two bookcases (101-200)	63.70*	51.37*	37.23*	27.44*	69.99*	42.60*	55.93*	57.89*	53.48*
	(5.30)	(7.04)	(9.34)	(2.99)	(4.79)	(4.75)	(5.01)	(5.30)	(4.23)
More than two bookcases	65.35*	60.37*	54.96*	24.77*	78.56*	49.81*	67.75*	65.88*	62.61*
(>200)	(5.48)	(7.61)	(8.85)	(3.31)	(4.62)	(4.51)	(5.06)	(5.26)	(4.75)
Living with both parents	14.04*	-1.86	18.66*	1.79	7.18$^+$	0.50	5.19°	8.34*	15.48*
	(3.59)	(4.90)	(5.33)	(2.23)	(2.89)	(2.57)	(3.14)	(2.45)	(2.89)
Born in country	-13.16$^+$	8.71	22.34*	-6.07$^+$	2.05	14.37*	30.30*	24.27*	1.56
	(5.76)	(6.18)	(4.85)	(3.06)	(4.31)	(5.06)	(4.01)	(4.06)	(4.57)
Female	-19.67*	-10.68*	-5.59$^+$	-9.79*	-10.56*	-9.70*	-2.26	-13.26*	-9.01*
	(4.93)	(3.01)	(2.27)	(1.48)	(2.23)	(2.05)	(2.02)	(2.01)	(2.33)
Age	-26.67*	-29.41*	2.42	-12.85*	8.79$^+$	-20.97*	-1.63	-17.11*	-22.09*
	(2.45)	(2.99)	(3.81)	(0.90)	(4.14)	(1.44)	(3.13)	(3.47)	(2.61)
Upper grade	54.68*	60.93*	40.33*	43.20*	27.18*	59.25*	39.56*	60.23*	45.99*
	(5.32)	(6.80)	(4.54)	(2.22)	(5.84)	(2.45)	(4.55)	(5.51)	(4.44)
Above upper grade	–	–	–	–	–	–	74.06*	118.93*	–
							(7.54)	(9.23)	
Community location									
Geographically isolated	6.71	–	6.98	-20.87*	12.15°	-46.10*	-19.35	4.85	-28.90*
	(12.83)		(7.42)	(4.99)	(6.71)	(2.22)	(13.76)	(14.67)	(7.95)
Close to town center	5.62	15.01	7.11	0.38	-3.31	2.37	10.04*	-5.74	-4.11
	(6.47)	(10.67)	(5.74)	(3.00)	(5.08)	(4.52)	(3.88)	(8.85)	(6.64)
Imputation controls	yes	yes	yes	yes	yes	yes	yes	yes	yes
Students [Unit of observation]	6203	4084	5736	6753	5776	7596	8855	11722	10973
Schools [Unit of clustering]	132	95	249	142	128	154	270	327	183
R^2	0.180	0.207	0.147	0.200	0.214	0.205	0.232	0.272	0.185
R^2 (without imputation controls)	0.162	0.187	0.135	0.196	0.200	0.199	0.219	0.264	0.175

Significance levels (based on clustering-robust standard errors): * 1%. – $^+$ 5%. – $^\circ$ 10%.

Table 4: Family-Background Effects in Europe vs. the United States

Least-squares regression within each country, weighted by students' sampling probabilities.
Dependent variable: TIMSS math test score. Clustering-robust standard errors in parentheses.

	All countries	Interaction with Europe dummy
Parents' education		
Some secondary	16.56$^+$	-12.26$^°$
	(7.22)	(7.34)
Finished secondary	17.27$^+$	-4.39
	(7.33)	(7.41)
Some after secondary	30.83*	-8.73
	(7.01)	(7.17)
Finished university	52.01*	-20.08$^+$
	(8.02)	(8.15)
Books at home		
One shelf (11-25)	9.25$^+$	7.60$^°$
	(3.70)	(3.94)
One bookcase (26-100)	34.82*	2.97
	(3.58)	(3.84)
Two bookcases (101-200)	53.42*	-0.39
	(4.20)	(4.46)
More than two bookcases	62.41*	-0.87
(>200)	(4.67)	(4.90)
Living with both parents	15.40*	-9.69*
	(2.82)	(2.96)
Born in country	2.12	12.63*
	(4.69)	(4.92)
Female	-8.92*	0.00
	(2.32)	(2.48)
Age	-22.21*	3.47
	(2.64)	(2.73)
Upper grade	46.15*	4.96
	(4.42)	(4.56)
Above upper grade	111.60*	–
	(3.29)	
Community location		
Geographically isolated	-28.59*	25.77*
	(7.68)	(8.56)
Close to town center	-6.65	9.43
	(6.30)	(6.50)
Imputation controls	yes	
Country dummies	yes	
Students [Unit of observation]	115406	
Schools [Unit of clustering]	2932	
R^2	0.262	
R^2 (without imputation controls)	0.253	

Significance levels (based on clustering-robust standard errors): * 1%. – $^+$ 5%. – $^°$ 10%.

Figure 1: Quantile Regression Estimates of Family-Background Effects

Coefficients on the four books-at-home categories in the model of Table 3. – Horizontal lines: WLS estimates. – Curved lines with dots: Quantile regression estimates for 0.05 intervals. – Categories (residual = less than one shelf): ●— One shelf. – ●— One bookcase. – ●— Two bookcases. – ●— More than two bookcases.
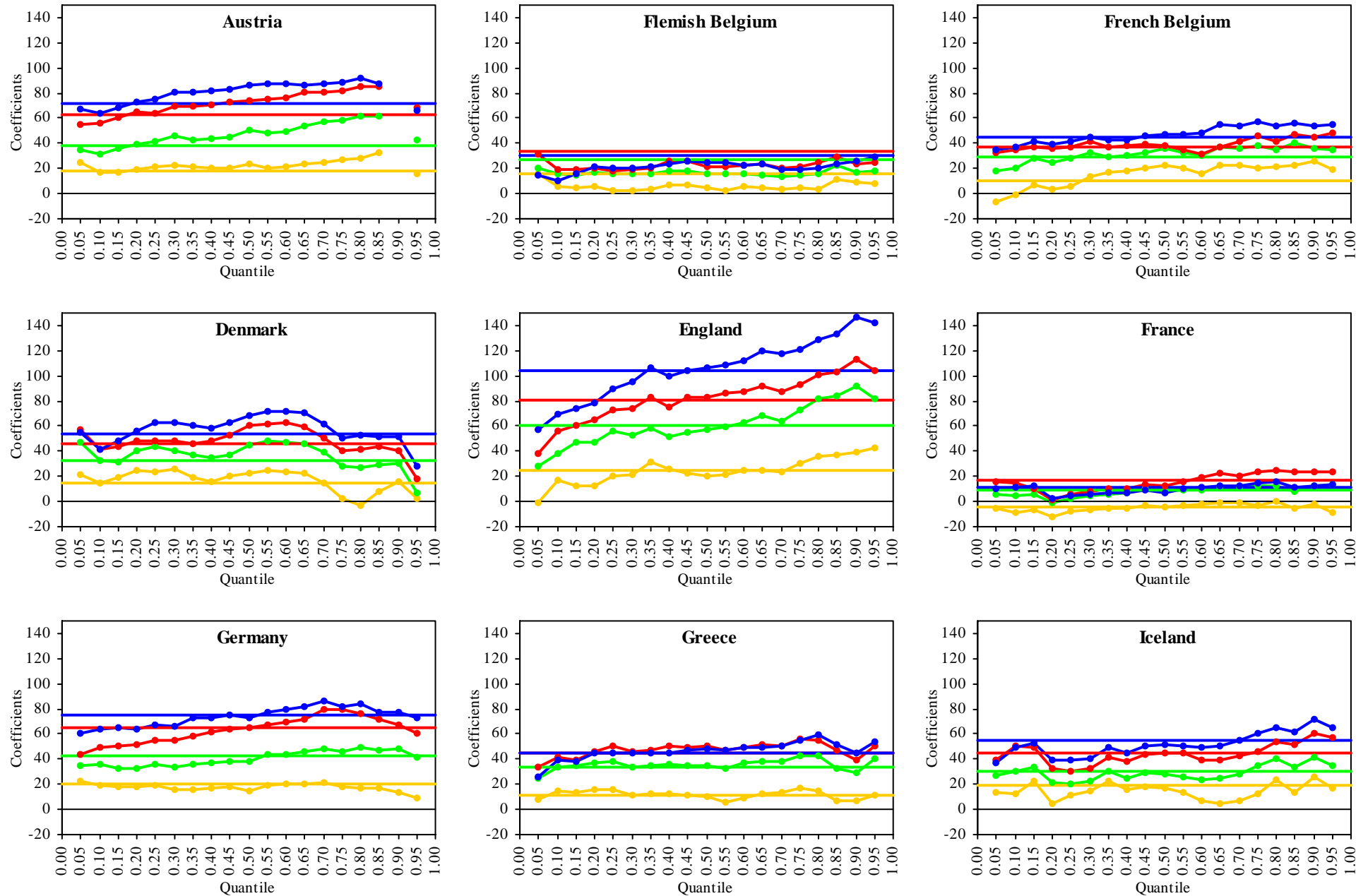
Figure 1 (cont.)
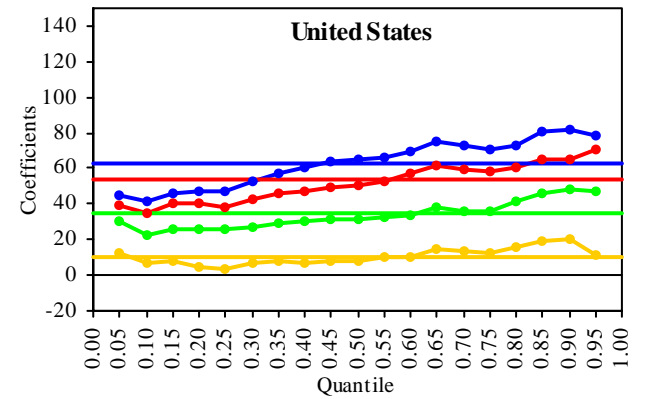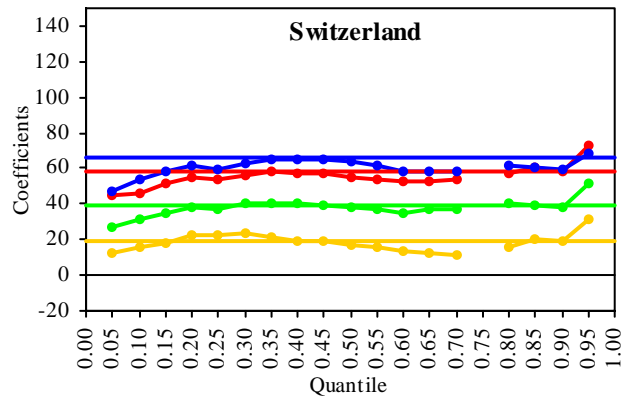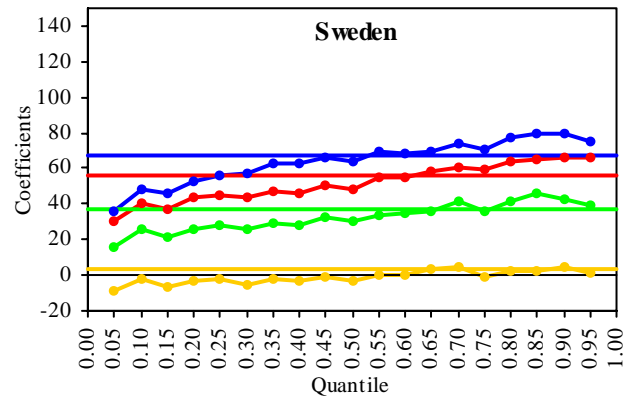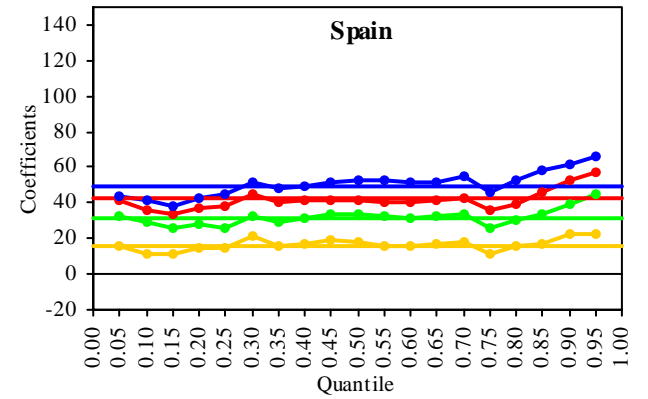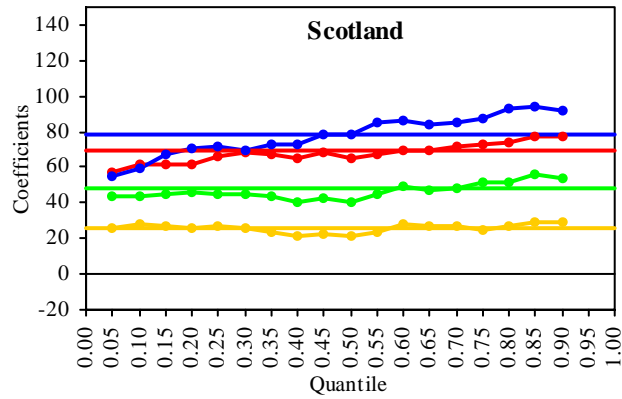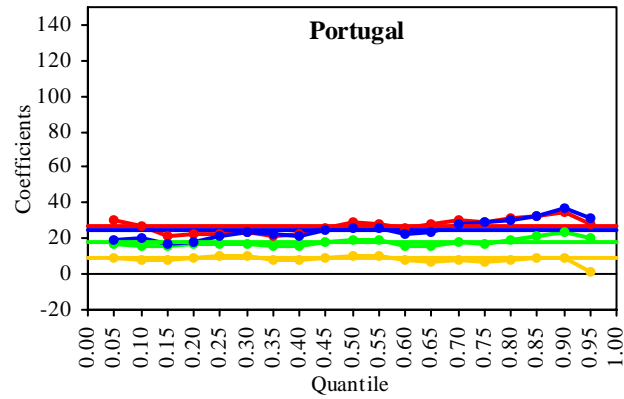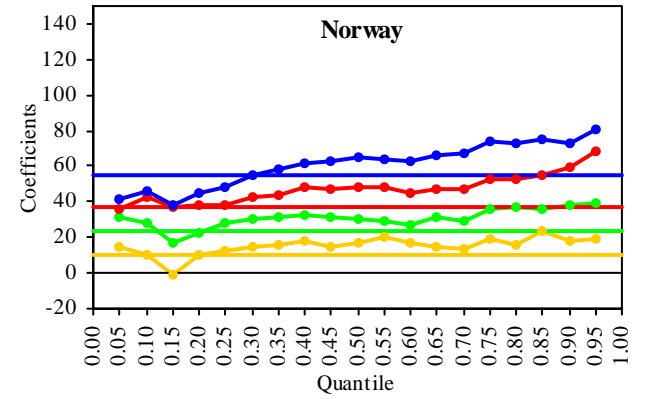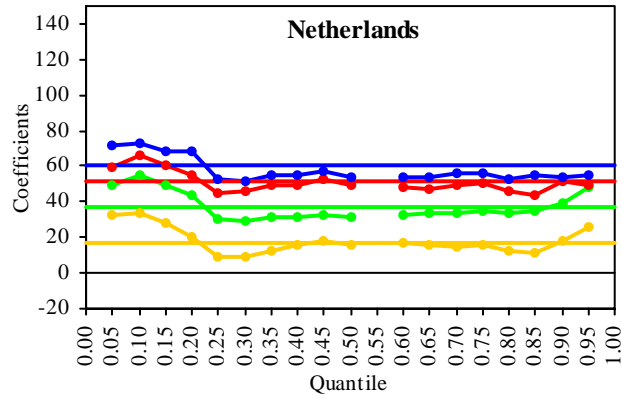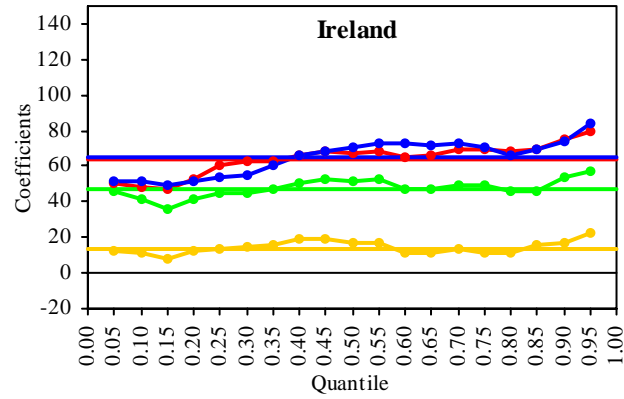
Figure 2: Family-Background Effects and Mean Performance
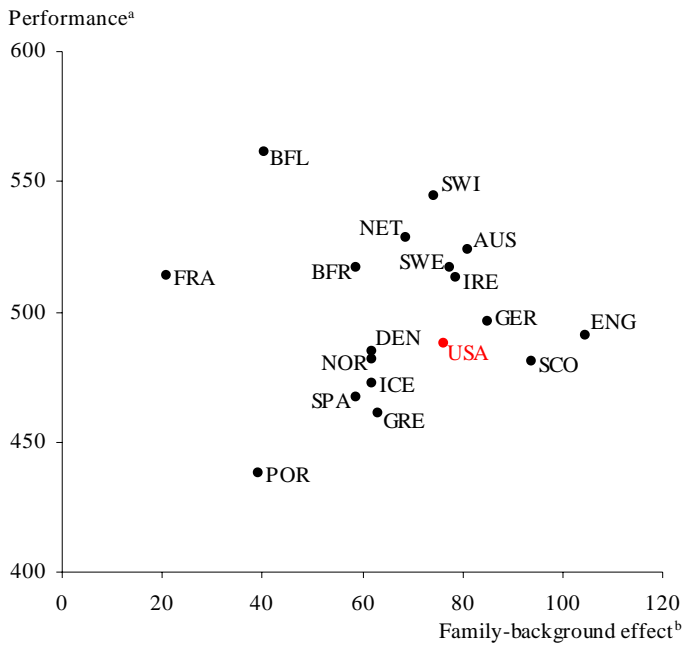
Performance[a]

Notes: [a] Mean performance on the TIMSS math test (cf. Table 1). – [b] Performance difference between students with more than two bookcases at home and students with less than one shelf of books at home, controlling for the variables reported in Table 3 except for parental education.

Appendix 1: Imputation of Missing Data within Each Country

Some students and school principals failed to answer some questionnaire items in the background questionnaires. Table A1 reports the share of missing values for each variable in each country. For the analyses in this paper, data for missing responses in the TIMSS questionnaires were imputed within each country based on a method that relates the observations from students with original data to a set of "fundamental" explanatory variables available for all students.

Specifically, the following set of "fundamental" variables F has data available for virtually all students in most countries: grade level; student sex; student age; four dummies for the parents' education level; four dummies for the number of books in the student's home; and three dummies for the community location of the schools. Missing data on variables within F were imputed by the median category observed at the lowest level available, i.e., either the class median, the school median, or the country median.

The variables in F were then used to impute missing data on the remaining variables M for each student i within each country. Let S denote the set of students j with available data for M. Using the students in S, the variable M was regressed on F:

$$M_{j \in S} = F_{j \in S}\phi + \varepsilon_{j \in S} \tag{A1}$$

Since the M variables considered in this paper are dichotomous (binary) variables, the regression model was a probit model was used, weighting each student by her sampling probability. Finally, the coefficients ϕ from these regressions and the data on F_i were used to impute the value of M_i for the students with missing data:

$$\tilde{M}_{i \notin S} = F_{i \notin S}\phi \tag{A2}$$

The coefficients estimated by the probit models were used to forecast the probability of occurrence associated with each category for the students with missing data, and the category with the highest probability was imputed. This data imputation technique was applied within each country individually, resulting in a complete data set for all the students sampled in TIMSS.

Appendix 2: Appendix Tables

Table A1: Missing Values

Fraction of students with missing data, not weighted.

	AUS	BFL	BFR	DEN	ENG	FRA	GER	GRE	ICE
Parents' education	0.22	0.33	0.35	0.42	1.00	0.45	0.29	0.17	0.23
Books at home	0.04	0.01	0.02	0.06	0.02	0.04	0.02	0.02	0.02
Living with both parents	0.07	0.02	0.02	0.06	0.02	0.05	0.03	0.04	0.05
Born in country	0.03	0.00	0.02	0.05	0.02	1.00	0.01	0.01	0.01
Sex	0.03	0.00	0.02	0.02	0.00	0.04	0.01	0.00	0.00
Age	0.03	0.00	0.03	0.02	0.00	0.07	0.03	0.00	0.00
Community location	0.13	0.10	0.17	0.19	0.15	0.11	0.40	0.03	0.10

Table A1 (cont.)

	IRE	NET	NOR	POR	SCO	SPA	SWE	SWI	USA
Parents' education	0.15	0.29	0.35	0.10	0.49	0.16	0.38	0.22	0.10
Books at home	0.02	0.04	0.02	0.01	0.07	0.01	0.02	0.02	0.02
Living with both parents	0.03	0.04	0.01	0.02	0.08	0.03	0.03	0.02	0.03
Born in country	0.01	0.04	0.01	0.01	0.06	0.01	0.01	0.01	0.02
Sex	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Age	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Community location	0.04	0.19	0.14	0.06	0.18	0.06	0.08	0.13	0.15

Table A2: Family Background and Science Performance

Least-squares regression within each country, weighted by students' sampling probabilities.
Dependent variable: TIMSS science test score. Clustering-robust standard errors in parentheses.

	AUS	BFL	BFR	DEN	ENG	FRA	GER	GRE	ICE
Parents' education									
Some secondary	–	-3.11	2.99	–	–	5.60	–	8.71$^+$	17.65$^+$
		(7.17)	(11.01)			(5.91)		(3.55)	(8.27)
Finished secondary	18.70*	7.10	15.35	10.23	–	12.39°	7.59°	19.85*	16.24°
	(5.95)	(6.12)	(9.91)	(7.93)		(6.38)	(3.90)	(3.42)	(8.53)
Some after secondary	–	28.68*	21.34$^+$	29.79*	–	21.30*	18.88*	19.48*	29.29*
		(8.68)	(10.73)	(8.01)		(6.86)	(5.54)	(4.32)	(7.41)
Finished university	30.50*	24.05*	29.42*	29.17*	–	26.84*	22.81*	37.39*	33.61*
	(7.45)	(6.46)	(10.83)	(7.88)		(6.25)	(5.53)	(4.37)	(8.15)
Books at home									
One shelf (11-25)	17.80*	14.85$^+$	19.37*	20.54$^+$	30.03*	8.95	32.28*	13.99*	-5.48
	(5.34)	(5.92)	(5.86)	(8.89)	(6.30)	(5.47)	(5.71)	(4.40)	(15.91)
One bookcase (26-100)	38.07*	24.08*	37.04*	34.82*	63.98*	24.64*	56.43*	34.94*	12.82
	(5.48)	(5.62)	(5.81)	(7.44)	(6.45)	(4.88)	(5.30)	(4.69)	(14.14)
Two bookcases (101-200)	59.14*	35.01*	50.94*	51.75*	91.62*	33.23*	78.56*	42.92*	22.93
	(5.58)	(5.07)	(5.54)	(7.91)	(6.91)	(5.36)	(6.70)	(5.39)	(15.28)
More than two bookcases	69.18*	34.66*	55.32*	61.86*	121.06*	29.40*	90.76*	44.35*	37.13$^+$
(>200)	(5.95)	(5.57)	(5.12)	(7.44)	(7.60)	(5.27)	(5.61)	(5.23)	(14.39)
Living with both parents	-3.61	-1.47	-7.89$^+$	-2.12	0.75	4.94°	1.94	6.91*	7.34°
	(3.66)	(3.54)	(3.19)	(4.05)	(4.63)	(2.97)	(3.73)	(2.60)	(3.77)
Born in country	44.14*	2.57	8.60	25.41*	22.17$^+$	–	33.02*	5.88	6.91
	(6.88)	(8.02)	(5.78)	(7.95)	(8.73)		(5.22)	(4.67)	(5.49)
Female	-17.05*	-16.49*	-19.74*	-27.73*	-19.89*	-19.69*	-20.34*	-15.02*	-15.10*
	(3.46)	(4.45)	(3.23)	(2.53)	(5.04)	(2.37)	(3.49)	(2.35)	(2.84)
Age	-18.97*	-18.63*	-17.13*	-15.04*	19.33*	-16.41*	-15.86*	-10.02*	7.43°
	(2.92)	(2.93)	(1.90)	(3.24)	(5.25)	(1.77)	(2.73)	(3.64)	(4.48)
Upper grade	57.24*	46.26*	48.94*	55.15*	21.66*	60.68*	46.93*	56.24*	23.19*
	(4.51)	(3.91)	(3.52)	(4.40)	(5.45)	(2.89)	(4.29)	(4.61)	(7.29)
Above upper grade	–	–	–	–	–	–	–	–	–
Community location									
Geographically isolated	47.91*	–	–	-12.44	-9.77	–	10.52	-13.38°	-15.48$^+$
	(5.40)			(9.47)	(8.54)		(26.34)	(7.86)	(6.77)
Close to town center	14.76$^+$	-6.42	7.45	-10.60$^+$	-12.15	2.81	6.84	11.98*	-2.69
	(6.58)	(5.26)	(5.07)	(5.21)	(7.70)	(3.70)	(8.73)	(4.27)	(5.10)
Imputation controls	yes	yes	yes	yes	yes	yes	yes	yes	yes
Students [Unit of observation]	5786	5662	4883	4370	3579	6014	5763	7921	3730
Schools [Unit of clustering]	129	141	120	153	127	134	137	156	155
R^2	0.175	0.113	0.183	0.155	0.178	0.183	0.210	0.180	0.114
R^2 (without imputation controls)	0.162	0.108	0.170	0.133	0.172	0.171	0.181	0.156	0.092

Significance levels (based on clustering-robust standard errors): * 1%. – $^+$ 5%. – $^\circ$ 10%.

	IRE	NET	NOR	POR	SCO	SPA	SWE	SWI	USA
Parents' education									
Some secondary	7.84	26.82*	–	7.17*	–	10.60*	–	–	-9.81
	(5.70)	(8.70)		(2.44)		(2.87)			(10.16)
Finished secondary	11.82+	31.63*	5.80	12.94*	-4.73	19.57*	13.69*	21.65*	5.22
	(5.51)	(9.51)	(6.45)	(4.27)	(5.36)	(3.74)	(4.99)	(3.12)	(10.18)
Some after secondary	22.41*	49.55*	21.69*	23.73*	12.30+	9.63*	13.93+	22.85*	18.55°
	(5.22)	(8.43)	(5.39)	(4.87)	(5.37)	(3.53)	(5.55)	(4.52)	(9.68)
Finished university	30.81*	42.27*	26.60*	36.18*	31.25*	19.17*	29.44*	38.55*	34.47*
	(5.67)	(9.64)	(6.03)	(4.46)	(5.76)	(3.93)	(5.10)	(4.58)	(10.08)
Books at home									
One shelf (11-25)	24.35*	6.06	20.25+	6.53°	30.64*	12.23+	17.13+	19.75*	15.78*
	(5.12)	(6.05)	(10.03)	(3.31)	(5.05)	(4.91)	(6.79)	(5.27)	(4.82)
One bookcase (26-100)	51.87*	22.67*	34.54*	14.96*	50.76*	28.58*	43.75*	39.45*	48.24*
	(5.27)	(5.61)	(9.35)	(3.30)	(4.34)	(4.68)	(6.39)	(4.54)	(4.81)
Two bookcases (101-200)	71.79*	40.33*	51.32*	21.78*	82.09*	38.80*	66.53*	55.97*	67.22*
	(5.14)	(6.57)	(9.03)	(3.49)	(5.27)	(4.98)	(6.72)	(4.84)	(5.16)
More than two bookcases (>200)	74.97*	46.82*	66.05*	30.70*	93.53*	45.33*	78.55*	69.22*	79.10*
	(5.94)	(6.36)	(9.10)	(3.99)	(5.10)	(5.07)	(6.30)	(5.05)	(6.01)
Living with both parents	4.69	-3.23	6.98°	-1.95	6.68+	0.23	2.16	-3.92	14.37*
	(3.36)	(4.83)	(3.60)	(2.60)	(3.30)	(3.21)	(3.36)	(2.48)	(3.51)
Born in country	-16.06*	23.94*	36.11*	-2.90	-9.03°	12.50+	41.81*	34.64*	17.61*
	(5.39)	(6.07)	(5.99)	(3.89)	(5.12)	(5.63)	(4.16)	(3.63)	(4.97)
Female	-19.10*	-18.68*	-14.77*	-19.92*	-20.40*	-21.64*	-11.02*	-20.47*	-15.14*
	(4.02)	(2.98)	(2.56)	(1.79)	(2.49)	(1.96)	(1.97)	(2.10)	(2.68)
Age	-16.55*	-17.98*	4.72	-11.68*	12.60*	-15.60*	0.73	-10.03*	-17.24*
	(2.42)	(3.25)	(3.73)	(1.13)	(4.13)	(1.78)	(2.93)	(3.06)	(2.92)
Upper grade	58.96*	65.69*	39.59*	62.00*	36.45*	54.49*	43.23*	50.53*	43.01*
	(5.08)	(5.53)	(4.70)	(2.27)	(5.56)	(2.64)	(4.39)	(4.60)	(4.92)
Above upper grade	–	–	–	–	–	–	74.97*	100.93*	–
							(7.00)	(8.00)	
Community location									
Geographically isolated	-0.67	–	16.44*	-13.90*	15.60°	-37.70*	-5.03	-8.93	-40.68*
	(13.34)		(5.04)	(3.92)	(9.16)	(1.92)	(8.23)	(10.68)	(9.11)
Close to town center	2.86	13.58°	1.63	3.35	-8.06	2.86	8.83+	-5.22	-13.79+
	(5.30)	(8.13)	(5.13)	(3.03)	(5.08)	(4.34)	(3.59)	(6.40)	(6.07)
Imputation controls	yes	yes	yes	yes	yes	yes	yes	yes	yes
Students [Unit of observation]	6203	4084	5736	6753	5776	7596	8855	11722	10973
Schools [Unit of clustering]	132	95	249	142	128	154	270	327	183
R^2	0.178	0.203	0.140	0.216	0.231	0.165	0.236	0.255	0.174
R^2 (without imputation controls)	0.160	0.185	0.127	0.215	0.217	0.158	0.225	0.247	0.161

Significance levels (based on clustering-robust standard errors): * 1%. – + 5%. – ° 10%.

Table A3: Family-Background Effects in Europe vs. the United States in Science

Least-squares regression within each country, weighted by students' sampling probabilities.
Dependent variable: TIMSS science test score. Clustering-robust standard errors in parentheses.

	All countries	Interaction with Europe dummy
Parents' education		
Some secondary	-4.79	10.29
	(9.26)	(9.35)
Finished secondary	7.16	4.49
	(8.81)	(8.88)
Some after secondary	20.01[+]	1.41
	(8.62)	(8.73)
Finished university	36.79[*]	-9.61
	(9.17)	(9.28)
Books at home		
One shelf (11-25)	15.03[*]	5.09
	(4.76)	(4.98)
One bookcase (26-100)	49.17[*]	-8.94[°]
	(4.86)	(5.08)
Two bookcases (101-200)	67.25[*]	-9.83[°]
	(5.04)	(5.26)
More than two bookcases (>200)	79.62[*]	-11.59[°]
	(5.79)	(5.99)
Living with both parents	14.78[*]	-13.16[*]
	(3.55)	(3.66)
Born in country	18.57[*]	0.96
	(5.17)	(5.40)
Female	-15.13[*]	-3.10
	(2.64)	(2.76)
Age	-17.49[*]	5.62[°]
	(2.94)	(3.02)
Upper grade	43.31[*]	8.72[°]
	(4.90)	(5.02)
Above upper grade	102.21[*]	–
	(2.96)	
Community location		
Geographically isolated	-40.19[*]	40.05[*]
	(8.96)	(9.62)
Close to town center	-18.15[*]	19.55[*]
	(5.98)	(6.15)
Imputation controls	yes	
Country dummies	yes	
Students [Unit of observation]	115406	
Schools [Unit of clustering]	2932	
R^2	0.243	
R^2 (without imputation controls)	0.235	

Significance levels (based on clustering-robust standard errors): [*] 1%. – [+] 5%. – [°] 10%.