Working Paper Series
No. 38/2008

SOCIOECONOMIC RELATED INEQUALITIES IN STUDENTS' MATHEMATICS ACHIEVEMENT IN THE EUROPEAN UNION

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December 2008

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Universidade do Minho

Fundação para a Ciência e a Tecnologia
MINISTÉRIO DA CIÊNCIA E DA TECNOLOGIA

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ABSTRACT

This paper examines the degree of socioeconomic related inequalities in mathematics achievement for students from the European Union and presents some possible sources for the exhibited differences between countries. We applied a methodology which has been used in health economics literature namely by Wagstaff *et al.* (1991) and Kakwani *et al.* (1997). We selected parental highest level of education as a proxy for students' socioeconomic background. Results confirm a significant inequality in achievement favouring the higher socioeconomic groups in all countries. Germany has the greatest socioeconomic related mathematics achievement inequality, followed by Greece, Great Britain and Portugal. Sweden, by contrast, is the country where the socioeconomic related inequality in PISA maths scores seems to be lower. The paper also decomposes the inequality index into the contributions of some socioeconomic factors. Socioeconomic inequality has a sizeable contribution for socioeconomic related inequality in mathematic achievement in every country. Cross-country comparison shows that in some countries, such as Belgium, Denmark or Great Britain, the impact of socioeconomic background on students' achievement appears to be more important to determine the "excess" of socioeconomic related inequality in mathematics achievement than the inequality in the distribution of the socioeconomic variable. In other group of countries, that includes Italy, Luxembourg, Portugal and Spain, it is the inequality in the distribution of the socioeconomic variable itself that mainly explains the "excess" of socioeconomic related inequality in mathematics achievement. Portugal is a striking case exhibiting poor mathematic score, a high level of socioeconomic inequality and a high level of socioeconomic related inequality in students' performance.

Moreover, the inequality in family books possession is also a strong predictor for inequality in students' math achievement.

JEL Code: I29

Keywords: Educational economics, input output analysis

1. Introduction

In a recent report the European Union Commission (2006) emphasises that the future of European competitiveness will depend to a great extent of the Europeans' ability to develop competences on mathematics (as well as on science and on technology). Indeed, mathematical literacy is a key competence in modern societies. It is a requirement to the acquisition of the academic background needed to explore the opportunities of an increasingly knowledge and technologically oriented society, which is likely to affect individual employment and earnings history. The critical importance of mathematical education for individuals and society provides evidence on which factors affect maths students' performance as a crucial policy tool. Education literature has been pointing out that the students' socioeconomic background plays a crucial role in explaining educational inequalities.

Beyond the goal of increasing the overall achievement on maths, there are other educational policy objectives concerning equity and social mobility that are core issues of education policies in European Countries. Despite all attempts to democratize education, educational achievement continues to be strongly linked to the parents' social background. The existence of a intergenerational effect on educational performance as well as its strong role while a source of inequality in education is found virtually in every study on education process, including studies using PISA data set [Fertig & Schmidt (2002), Fertig (2003), Fuchs & Woesseman (2004)]. A number of explanations for the connection between parents' background and their children educational performance have been proposed. The most widespread view is that parents holding a high social background, in particular more educated parents are more likely to invest more and better on human capital (Becker, 1964).

The main objective of this study is to provide evidence on socioeconomic related inequalities in students' mathematics achievement, within 15 European countries, using the most recent disclosed data from PISA project. Moreover, we explore the potential causes for cross-country differences by decomposing the estimated indexes of socioeconomic related inequality in achievement into the contributions of some selected variables (following Wagstaff et al., 2003). We believe those variables are likely to affect the mathematics achievement and have a contribution for the estimated socioeconomic related inequality. The contribution of each variable for the estimated socioeconomic related inequality can be viewed as the result of two combined factors. One factor measures the elasticity of educational attainment relative to a specific variable. The other factor is the socioeconomic concentration index for the selected variable. Thence, if there are low social-economic inequalities within a country but there is a great impact of a small variation on students' social or economic characteristics over their educational performance, then this country is likely to experience a relative high socioeconomic related educational inequality amongst its students. Or, by contrast, if there are high socioeconomic inequalities within a country but variations in socioeconomic characteristics of students are meaningless to explain educational performance, then this country may be experiencing a relatively low level of socioeconomic related educational inequality.

The understanding of these mechanisms can be crucial to the educational policy design and to its role in promoting equal opportunities for all as well as to promote social mobility. As European countries are vary heterogeneous regarding their socioeconomic inequalities indicators, and given the crucial weight the European Union has been putting on education, especially on mathematical literacy, we strongly believe this study can be useful and insightful to better understand the current debate on educational reforms.

In order to analyse the above mentioned educational issues, we applied a methodology which has been used in health economics literature to analyse income-related inequalities in health, namely by Wagstaff *et al.* (1991) and Kakwani *et al.* (1997).

The paper is organised according to the following framework: in the next section, we set up the methods used; section three describes data and variables; section four summarises the main results. Finally, section five materialises some conclusions and gives some insight on policy implications.

2. Methodology

2.1 Measurement of inequality

In the present analysis, we use a concentration index (*CI*) as a measure of socioeconomic-related inequality in mathematics achievement. This method is similar to those that have been used in health inequality literature and first applied by Wagstaff *et al.* (1991). Recent work includes Van Doorslaer et al. (1997) and Van Doorslaer, & Koolman (2004).

The concentration index *CI* differs from the *Gini* index because when determining *CI,* the ranking variable and the variable of interest are different. This framework has the advantage that a redistribution of the variable of interest does not need to affect the ranking (because it is based upon other variable). Following this approach, *CI* is used as a bivariate measure of inequality and it measures inequality in one variable (mathematic tests scores, in our study) as a function of other variable's ranking (socioeconomic status, in our study).

First, let us consider a continuous cardinal measure of mathematics achievement, hereafter represented by A_i. Afterwards, consider an achievement-concentration curve *L*(*s*) which plots the cumulative proportion of the population ranked by a socioeconomic characteristic against the cumulative proportion of the mathematical achievement.

The concentration index, *CI*, is defined as twice the area between *L*(*s*) and the diagonal. When *L*(*s*) coincides with the diagonal, the concentration index is null meaning all socioeconomic group reports the same relative share of achievement, and therefore there is no socioeconomic related inequality in achievement.

If *L*(*s*) lies *above* the diagonal, the concentration index is negative, meaning that inequalities in performance exist whilst favouring members of society with lower economic status. If, by contrast, *L*(*s*) lies *below* the diagonal, the concentration index is positive meaning that socioeconomic inequalities in mathematics achievement favour the higher socioeconomic economic groups.

The further the curve *L*(*s*) lies from the diagonal highlighting a greater degree of socioeconomic related inequality. The minimum and maximum values of *CI,* using individual data, are -1 and +1. Ignoring, for simplicity of presentation, the fact that sampling weights will be necessary, *CI* is given by:

$$CI=\left(\frac{2}{\bar{A}}\right)\text{cov}(A_i,R_i) \qquad (1.),$$

where A_i represents the students' achievement, R_i is the individual's relative position in the socioeconomic variable ranking, and $\bar{A}$ stands for the mean level of achievement in the sample.

Kakwani *et al.* (1997) show that *CI* can be derived as the estimate of γ in the following convenient regression

$$2\sigma_R^2\left[\frac{A_i}{\bar{A}}\right]=\alpha+\gamma R_i+\varepsilon_i\,, \qquad (2.),$$

where (σ^2_R) is the variance of R_i, (α) is the constant term, (ε_i) is the error term, and as above mentioned, A_i is the individual's educational achievement. According to these authors, the estimate for γ is given by:

$$\hat{\gamma} = \frac{2}{n\bar{A}} \sum_{i=1}^{N} (A_i - \bar{A})(R_i - \frac{1}{2}) \qquad (3.),$$

and CI meets three basic requirements for an index in inequality; (i) it reflects the socioeconomic dimension (ii) it reflects the experience of the entire population and (iii) is sensitive to changes in the distribution of the population across socioeconomic groups.

2.2 Decomposing inequality

Another attractive feature springing up from the use of the concentration index as a socioeconomic related inequality in mathematics index is the possibility to incorporate an econometric model for the mathematics achievement and, subsequently, it proceeds to decomposing the inequality into the contributions of different variables (defined as regressors in equation 4.). A straightforward way of decomposing the measured degree of inequality into the contributions of the explanatory factors was proposed by Wagstaff et al. (2003) in the context of a linear additive explanatory model such as:

$$A_i = \alpha + \sum_k \beta_k x_{ki} + \rho_i, \qquad (4.)$$

where the x_k variables are the mathematics achievement determinants and ρ is the disturbance term. Given the relationship between A_i and x_{ki}, the concentration index CI can be written as: (Wagstaff et al. 2003):

$$CI = \sum_k \left(\frac{\beta_k \bar{x}_k}{\mu}\right) C_k + \frac{GC\varepsilon}{\mu} \qquad (5.)$$

where $\bar{x}_k$ is the mean x_k, C_k is the concentration index for each of the x_k variables, and $GC\varepsilon$ is the generalized concentration index for the disturbance term (C_k is defined analogously to CI).

According to equation 5., CI can be decomposed into two components: the first being the deterministic or "explained" component of the index and the second being the residual or unexplained component. The "unexplained" component reflects the socioeconomic related inequality in mathematics achievement that cannot be explained by systematic variation in the regressors (x_k) across socioeconomic groups.

The "explained" component is equal to the weight sum of the concentration indices of the regressors, where the weights are simply the elasticity of *A* with respect to each x_k, evaluated at sample means:

$$CI = \sum_k \eta_k \, C_k + \frac{GC\varepsilon}{\mu} \qquad (6.)$$

Decomposition clarifies how each determinant separately contributes to the total socioeconomic related inequality in mathematics achievement: each contribution is the result of (i) the impact of the variable on achievement as measured by its elasticity (η_k) and (ii) its degree of unequal distribution over socioeconomic levels (C_k).

To facilitate the assessment of the relative magnitude of these two components for each country i, we have computed, for the most relevant determinants, the *relative excess* elasticity $(\eta_{ki} - \eta_{kj}) / \eta_{kj}$ and the *relative excess* socioeconomic inequality $(c_{ki} - c_{kj}) / c_{kj}$, where j stands for the country with lowest socioeconomics related inequality in mathematics achievement. This decomposition is important from a public policy perspective, since in many cases education policy cannot address the actual socioeconomic distribution but it might be able to influence the elasticity of different determinants on the mathematics achievement.

3. Data and other variables

3.1 PISA data

Our analysis is based on data from PISA 2003 regarding the 15 European Union countries (European Union (15)). This was the second sweep of PISA which was carried in 41 countries, including 30 OECD countries. PISA is a three-year survey programme, coordinated by the OECD, aimed at measuring the educational attainment of 15-16 year old students. The 2003 survey covered reading, scientific literacy and problem solving, but the primary focus was on mathematical literacy[1].

[1] The data is publicly available PISA website (www.pisa.oecd.org).

Pisa is a complex survey data. Schools that participate in the survey have been chosen first, being therefore considered as the primary units. In the second stage, a random sample of students from the target population was drawn in every school. The sample is representative of the target population. PISA data has sampling weights for students and schools. We will take the survey characteristics of the data into account in our estimations.

To assess students' mathematical literacy, participants in the study responded to a standardized achievement test. In addition, students and school administrators had to respond to questionnaires wich provid contextual information describing the students, their families and the school characteristics.

Combining the available data, our sample consists of 94,050 observations. Data refer to students' information and involve 406 schools in the European Union (15).

3.2 Measurement of mathematical performance

According to the PISA framework, individual achievement in mathematics literacy is measured by a scaled score adjusted for reliability, difficulty and guessing, using Item Response Theory statistical procedures (See Hambleton, Rogers, & Swaminathan, 1991) These individual test scores are standardized in a subsequent step, so that the unconditional sample mean of the PISA 2003 scores equals e 500, and their unconditional sample standard error equals 100. PISA employed matrix sampling procedures where students responded to achievement items from different booklets.

PISA individual performance outcome is measured by a set of five plausible values that represent a set of random values for each student, selected at random from an estimated ability distribution of students with similar item response patterns and backgrounds. Mathematics achievement, in this paper, is measured by the mean value of the PISA reported plausible values.

3.3 Socioeconomic ranking variable

The socioeconomic variable used in the present study, to calculate R_i (ranking variable for the concentration index) is the student's highest parental education. Highest parental education rises up as a good proxy for socioeconomic status because of its strong and statistically significant correlation with the socioeconomic index estimated by PISA (Correlation = 0.8121). Moreover, the correlation is strong and consistent for each country in the sample.

3.4. Other variables in the achievement regression

The other variables selected as regressors in the mathematics achievement model (equation 5.) are:

1) Possession of *books* as a proxy for the students' cultural background. The values for this variable range from one to six according to the PISA codification;

2) *Gender* which is a dummy variable equal to 1 if the student's gender is female, 0 otherwise;

3) Citizen status which is a dummy variable equal to 1 if the student is a national citizen, 0 otherwise;

4) Full-*work mother* which is a dummy variable equal to 1 if the mother works full time, 0 otherwise;

5) Full-*work father* which is a dummy variable equal to 1 if the father works full time, 0 otherwise;

6) Family structure which is a dummy variable equal to 1 whether they are an intact nuclear family, 0 otherwise.

3.5 Descriptive statistics

Table 1 displays some descriptive statistics for mathematics achievement mathematics achievement and the explanatory variables used in this study, detailed by country. The average score of European students is 500 points, that is on the average of all OECD participating countries. Finland is the country with the best performance, where students score on average 44% more than the OECD average. Students from the Netherlands rank the second in

European Union (15). On the opposite direction, the European southern countries as well as the Luxembourg are ranked bellow OECD average. The country with lowest scores within European Union (15) is Greece, followed close by Portugal.

The huge differences in students' performance registered among European countries, and especially the observed differences between northern and southern European countries, are strong indicators of significant differences in the education systems across European countries and the presence of significant barriers for the desirable economic convergence as well as for the real construction of a European Union labour market.

The low qualifications of Portuguese and Spanish parents are striking, while Nordic parents are the ones holding higher qualifications. The indicator of possession of books does not strongly vary amongst countries. The education system with more immigrants appears to be the Luxembourg system. The immigration variable seems to attain similar values for the rest of the observed countries. The parents' activity variable shows a remarkable percentage of working mothers in Nordic countries as well as in Portugal.

(Table 1 here)

Data suggests that there is a positive relationship between average mathematics achievement mathematics achievement and average parental education per country. Further illustration is summarised in graph 1, where these two variables are plotted. Denmark stands out as the country with the highest average of the socioeconomic ranking level (as measured by the parental education level). Nonetheless, this country is not the country where students seem to perform better. Finland, The Netherlands and Belgium positions are slightly bellow on the average of the socioeconomic ranking level, but their students tend to have, on average, better results than the Danish students. Greece reports the lowest average mathematics achievement mathematics achievement scores, by far distant from what would be expected on the basis of this country average socioeconomic ranking level. On the other hand, Portugal has the lowest average socioeconomic ranking level and it is also among the countries unveiling lower average for the achievement variable.

4. Empirical results

4.1 Achievement regression model estimates

OLS estimates for the achievement regression model (equation 4.), by country, are presented in table 2. We deem important to materialise a few general remarks. As expected, the socioeconomic status (highest parental education) coefficient is positive and statistically significant in every country. The estimated coefficients, nonetheless, show differences amongst the European Union (15) countries. Countries with lower parental education return seem to include Portugal, Austria and Italy.

Regarding the other variables, our estimates converge for the main findings in the economics of education related literature. Overall, female students tend to perform worse than their male counterparts. Citizens do better than immigrants, except in Ireland and Great Britain where the estimated coefficients are not statistically significant.

Students living within an intact nuclear family tend to perform, on average, better than students within other types of family structure. Nonetheless, the size of the estimated coefficient diverges among countries and it is very small and not-statistically significant in the regressions for Finland, Austria and German.

Without any exception, the number of books at home is positively associated with mathematic achievement. Except for The Netherlands, where the father's employment status appears to matter. Indeed, students whose fathers have full-time jobs tend to perform better. On the other hand, the estimated coefficients on mothers as full-time workers have different signs across countries and tend to be small and not statistically significant.

(Table 2 here)

4.1 Socioeconomic related inequality in mathematic achievement

The concentration indexes, computed using regression (2.) are summarised in table 3. As expected, in all European Union (15) countries, achievement is unequally distributed, favouring the highest socioeconomic groups. All the estimated concentration indices are positive and statistically significant at conventional levels. Nonetheless, there can be pinpointed some substantial differences between European Union countries. Germany has the greatest estimated socioeconomic related mathematics achievement mathematics achievement inequality, followed by Greece, Great Britain, and Portugal. On the other hand, Sweden is the country where maths scores are less associated to socioeconomic groups, that is Sweden has the lowest socioeconomic related inequality in mathematic achievement. Therefore, we will use Swedish information as a reference to estimate relative excess of inequality as defined in the methodology section of this paper.

(Table 3 here)

4.3 Concentration indexes per socioeconomic variable

Concentration indexes for each variable were computed and are presented in table 4. The interpretation of the sign of the variable is straightforward: a positive (negative) sign of the concentration coefficients for each socioeconomic variable means that there exists a socioeconomic advantage (disadvantage) for those individuals having that particular characteristic.

We first look at the socioeconomic concentration index. It can be interpreted as a Gini coefficient for the socioeconomic status. Portugal outshines by far the greatest socioeconomic inequality amongst the 15 European Union countries. It is followed by Spain and Luxemburg but at great distance. By contrast, Belgium has the lowest socioeconomic inequality among the 15 European Union countries.

Keeping on looking at the results as disclosed in table 4, it is striking and insightful to see that families possessing more books tend to concentrate more amongst the highest socioeconomic groups. Sweden is the country with the lowest socioeconomic inequality in books possession, that is, households tend to have similar possession of books regardless f their socioeconomic status. On contrary, insofar as book possession is concerned, Portugal unveils the highest socioeconomic inequality, which reinforces the evidence that the country has a very high economic and cultural inequality. Full-time working parents are also concentrated amongst the highest socioeconomic, except in Luxemburg. The estimated coefficients for the citizen variable show that citizens tend to have a higher social economic status, but the same does not apply in the case of Denmark, Greece, Italy, Portugal and Spain.

Graph 2 plots the estimated socioeconomic inequality index against countries' mean achievement in mathematic. It shows that students from countries with lower socioeconomic inequality tend to perform better. A remarkable exception is Greece. Therefore, the persistence of social inequality appears to be bad for mathematic achievement.

Graph 3 shows a scattered diagram of socioeconomic related inequality in mathematics achievement mathematics achievement and socioeconomic inequality. The correlation is positive, significant at conventional levels but it is not as strong as expected (Correlation=0.257). The correlation becomes stronger if we ignore Portugal, as it is an outlier. Overall, the result suggests that socioeconomic education inequality is not a merely reflection of socioeconomic inequality.

Graph 4 plots the concentration index for books possession against the mean of mathematic achievement, for each country. The relation between cultural inequality in a society and the mean achievement in maths is less clear suggesting that within a range cultural inequality does not affect dramatically the mean achievement level. Nonetheless, it can be seen that the two countries with the lowest concentration index for books possession, have higher scores than OECD average. Additionally, Portugal that is the country with the highest cultural inequality, students perform poorly than the average. The decomposition will allow for analysing in more detail these findings.

4.4 **Decomposition of educational inequality**

The core issue is to determine as to how the various determinants contribute – or not - to the observed socioeconomic related inequality in mathematics achievement mathematics achievement in the European Union (15)?

The contributions of each variable to the degree of socioeconomic related mathematics achievement inequalities are presented in table 4. A positive (negative) x% contribution of the variable X on CI is to be interpreted as follows: socioeconomic related mathematics achievement inequality would, *ceteris paribus*, be x% lower if variable X were equally distributed across the socioeconomic range, or if variable X had a zero achievement elasticity.

(Table 4 here)

Some general findings emerge from the estimates. In all countries socioeconomic inequality itself, accounts for a significant and sizeable contribution: between 31% (Austria) and 56% (Ireland). Apart from parental academic background, the independent variable which seems to contribute more to the socioeconomic related inequality in mathematics achievement is the possession of books. Their importance varies widely, from 67.5% (Austria) to 31.5% (Sweden). Father employment status has a positive, but in general small, contribution to educational inequality. The contributions of the other variables are small and less straightforward to generalise.

Table 5 clarifies how social economic inequality contributes to the total socioeconomic related inequality in mathematic achievement, mainly separating the two components: the social economic concentration index ($Cpared$) and socioeconomic elasticity ($\eta pared$). The relative magnitude of the two components can be easily ascertained comparing the two composite terms relative to Sweden (the reference country). The findings are summarised in Table 6.

(Table 5 here)

(Table 6 here)

As expected, the observed cross-country differences in socioeconomic related inequality in mathematics achievement seem to stem, at same degree, from the contributions of the cross-country differences in the socioeconomic inequality *per se*. In countries exhibiting a low return on parental education, such as Austria, Finland, Italy, Luxembourg, Portugal and Spain, it is the socioeconomic inequality itself that seems to dominate the factors impacting on socioeconomic related inequality in mathematic achievement. In other words, socioeconomic related inequality in mathematics achievement can be mainly explained by high socioeconomic inequality rather than by large differences of parental background influence on performance. Therefore, for these countries the most appropriate policy measure to reduce the socioeconomic related inequality in mathematics achievement would be to reduce the socioeconomic inequality itself (e.g., by increasing the level of students' parents education with special educational programs).

One of the most striking cases seems to be Portugal. Portugal has the highest socioeconomic inequality and the second higher socioeconomic related inequality in students' mathematic achievement. Looking at the decomposition of the estimates, the socioeconomic related inequality in mathematics achievement is dominated by the high socioeconomic concentration, while the impact of parents' education appears to be smaller when compared to Sweden as well as to the other European Union countries being studied. The low elasticity of parents' education on mathematic achievement may result from unobservable parents' characteristics, such as lower quality of their own education, lower ability to make good investment, or lower dedication to their children education. Or, by contrast, it may be due to a more efficient school system that may be succeeding in reducing the impact of students' unfavourable backgrounds on mathematics achievement. Nonetheless, it should be noticed that Portugal does also display one of the poorest performances in PISA among the EU (15).

Second, for other group of EU(15) countries that includes Denmark, Finland, Belgium, Ireland, and the Netherlands, the differences in the socioeconomic related inequality in mathematics achievement appear to be dominated mainly by the socioeconomic elasticity on achievement. This implies that, for these countries, it seems that it is not so much the differences in socioeconomic inequality, but the large impact of a more favourable socioeconomic background on achievement, that matters for better explaining the socioeconomic related inequality in mathematic achievement. Take the case of Belgium. Belgium has a higher socioeconomic related inequality in mathematics achievement than Sweden and one of the highest in European Union (15). Nonetheless, in Belgium the estimated socioeconomic concentration is lower, meaning that the socioeconomic related inequality in mathematics achievement is mainly due to a strong impact of socioeconomic status on children achievement. As a consequence, the most appropriate policy measure to reduce the socioeconomic related inequality in mathematics achievement would be to reduce the association between socioeconomic status and mathematic achievement. The school system may play an important role on this goal.

Finally, for Germany and Greece, the excess of inequality attributable to socioeconomic differences, relative to Sweden, seem to stem from both higher socioeconomic concentration and higher elasticity.

The exercise of decomposing the contribution for the possession of books variable is presented in table 8 and table 9. In the case of books possession, data suggest that books are unequal distributed among households with possession being associated with parents' education. Moreover, possession of the books is strongly associated with math achievement. Relative to Sweden, all the other EU (15) show a more unequal distribution of books, as well as a greater impact of family possessions in the results.

Assuming that the possession of books is a good indicator of fostering cultural background, the result suggests that the policies which would best facilitate the access would increase the students' achievement and contribute to reduce the inequality in the results.

(Table 7 here)

(Table 8 here)

5. Conclusions and discussion

We believe that this paper does provide an important and insightful contribution to a better understanding of the socioeconomic related inequality in mathematics achievement within the European Union.

We found that every country in the European Union (15) has some degree of socioeconomic related inequality in mathematics achievement but it is especially high in Germany, Greece and Great Britain, while Sweden and Finland show a relatively low level of inequality. Decomposition clarified how each determinant separately contributed to the total socioeconomic related inequality in mathematics achievement. The contribution of each factor was also decomposed into two components: one component refers to each variable's effects on students' achievement as measured by their achievement elasticities, and the other corresponds to the degree of inequality in the distribution of the socioeconomic variable within the population.

The decomposition exercise suggests that the socioeconomic level and the possession of books at home (cultural background) are the most important drivers of the observed differences in socioeconomic related inequality in mathematic achievement, across the European Union (15) countries. According to our findings, the correlation between socioeconomic inequality and the socioeconomic related inequality in mathematics achievement is positive but weaker than we would anticipate. For example, Germany has the highest socioeconomic related inequality in students' mathematic achievement, although it is not the EU(15) country where parents' education is more unevenly distributed. Portugal, by contrast, has the highest socioeconomic inequality in the European Union (15), but it has a socioeconomic related inequality in mathematics achievement that is similar to Greece and Great-Britain. The main explanation for these results appears to be the differences in the impact of parents' education on their children mathematic achievement. Moreover, we found that socioeconomic inequality is bad for the students´ achievement.

In conclusion, reducing socioeconomic inequality would significantly reduce the socioeconomic related inequalities in students' mathematics achievement, but it is not the only path to reduce these inequalities. What also appears to be crucial, in some countries, is the impact of the socioeconomic variables on mathematic achievement. Therefore, public policies focusing on reducing the impact of students' unfavourable backgrounds may definitely contribute for more equitable results. Nonetheless, before being able to formulate policies, it is necessary to obtain more evidence on the causal pathways between mathematics achievement and parents' socioeconomic background.

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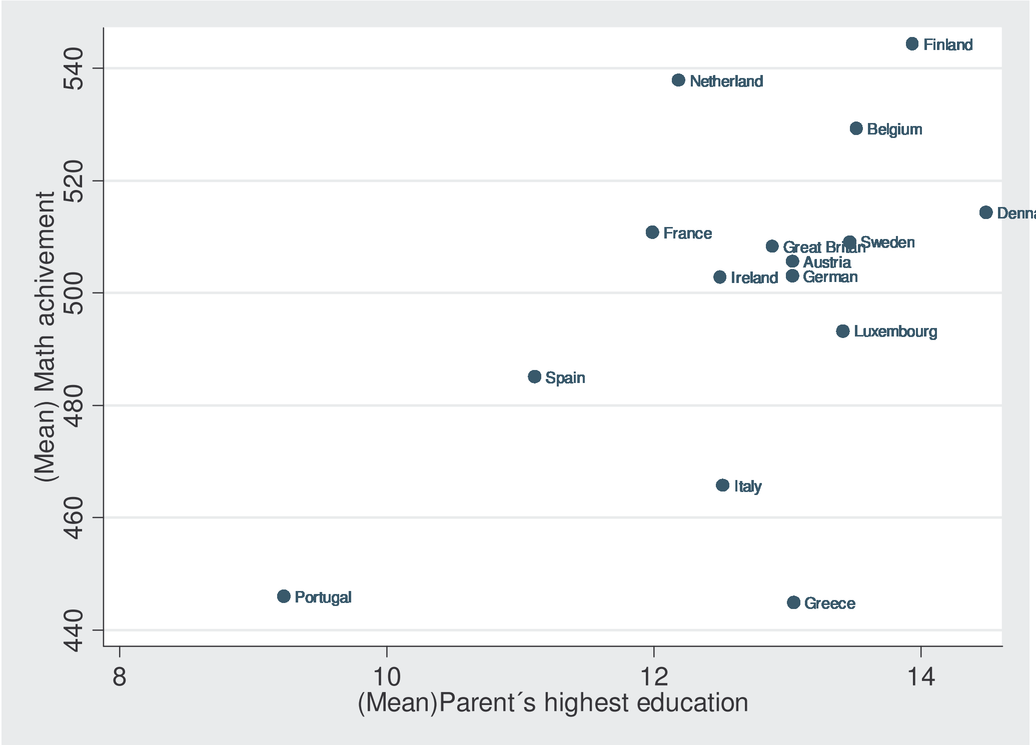
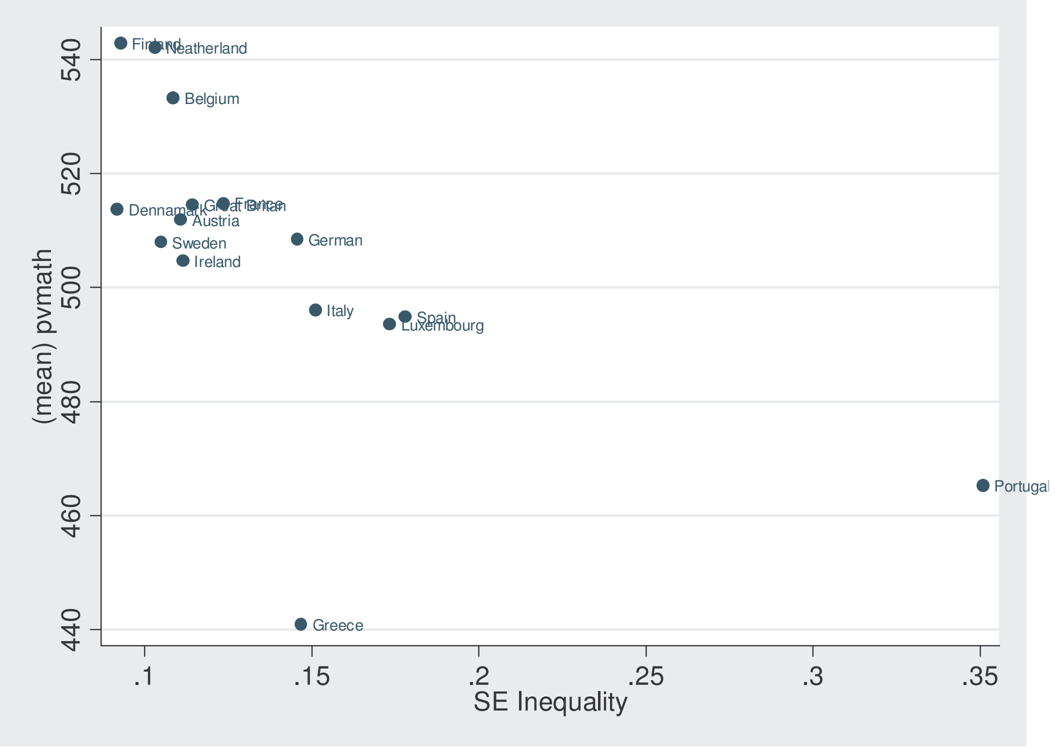
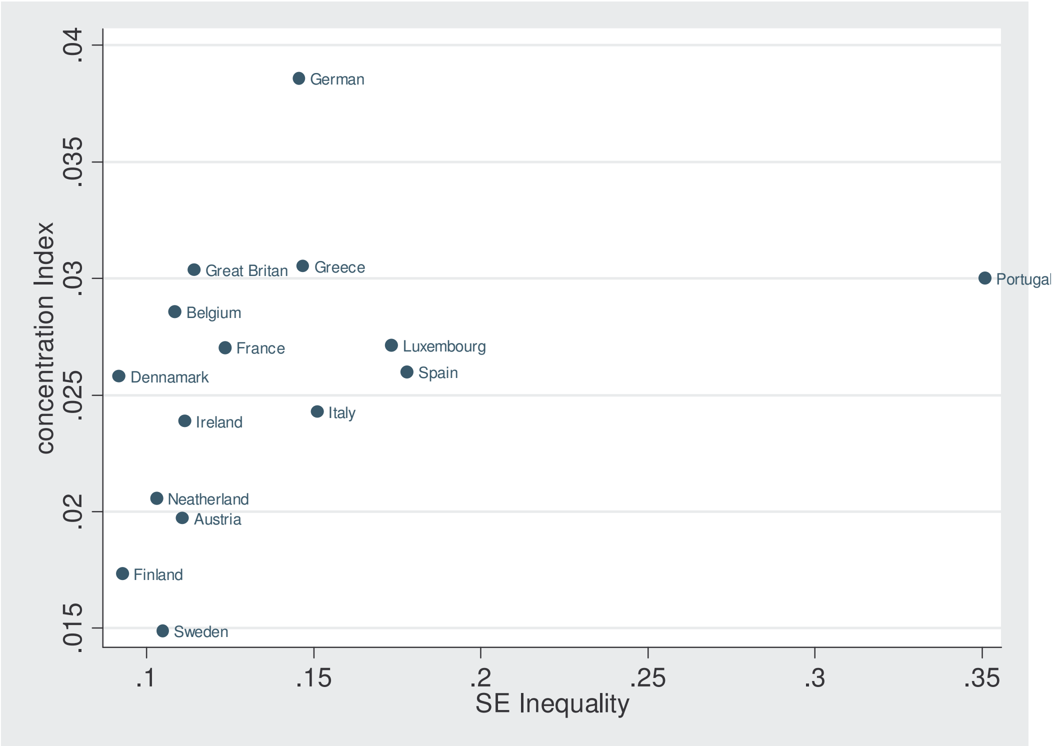
Graph 1 – Average socioeconomic ranking level and average students' mathematic performance by country



Graph 2 – Mathematics achievement and inequality in parents' education



Graph 3 - Socioeconomic related inequality in mathematics achievement and socioeconomic inequality measured by parental education



Graph 4 –Mathematics achievement and socioeconomic inequality in book possession

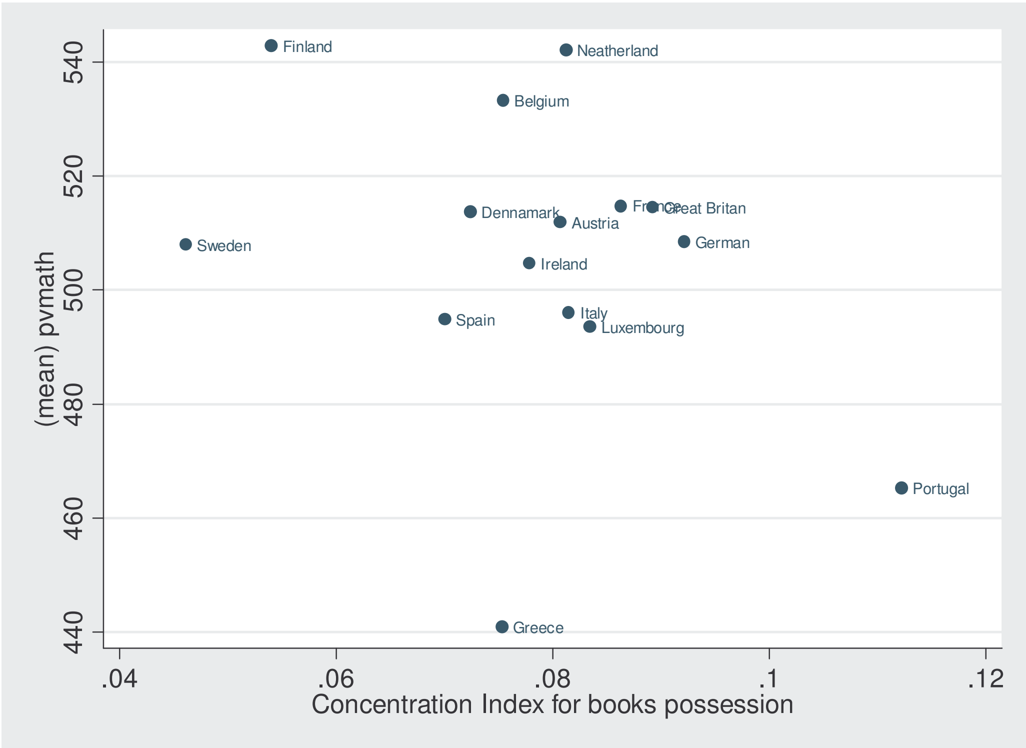


Table 1 – PISA weighted descriptive statistics

Country	*Maths Achievement*	*PARED (Highest parental education)*	*Books*	*Gender*	*Citizen*	*Work-mother*	*Work-father*	*Family*
Austria	505.61 (3.20)	13.04 (0.67)	3.38 (0.04)	0.50	0.90	0.38	0.86	0.76
Belgium	529.29 (2.24)	13.52 (0.58)	3.36 (0.03)	0.48	0.92	0.43	0.83	0.73
Denmark	514.29 (2.62)	14.49 (0.84)	3.55 (0.08)	0.51	0.95	0.69	0.85	0.66
Finland	544.29 (1.74)	13.94 (0.46)	3.52 (0.02)	0.50	0.96	0.72	0.82	0.69
France	510.80 (2.43)	11.99 (0.79)	3.36 (0.03)	0.53	0.95	0.52	0.84	0.70
German	502.99 (3.29)	13.04 (0.89)	3.63 (0.03)	0.50	0.91	0.33	0.82	0.75
Great Britain	508.26 (2.35)	12.89 (0.05)	3.52 (0.38)	0.53	0.94	0.48	0.85	0.65
Greece	444.91 (3.85)	13.05 (0.14)	3.23 (0.04)	0.52	0.90	0.43	0.84	0.71
Ireland	502.84 (2.37)	12.50 (0.74)	3.33 (0.38)	050	0.93	0.38	0.85	0.80
Italy	465.55 (2.95)	12.52 (0.74)	3.35 (0.27)	0.52	0.97	0.35	0.81	0.80
Luxembourg	493.21 (2.88)	13.42 (0.71)	3.52 (0.19)	0.51	0.79	0.33	088	0.74
Netherlands	537.82 (3.08)	12.19 (0.68)	3.36 (0.05)	0.49	0.95	0.27	0.86	0.79
Portugal	446.02 (3.37)	9.23 (0.16)	3.06 (0.04)	0.52	0.93	0.62	0.83	0.78
Spain	485.11 (2.32)	11.11 (0.12)	3.64 (0.33)	0.51	0.96	0.40	0.85	0.81
Sweden	509.05 (2.50)	13.47 (0.62)	3.90 (0.32)	0.50	0.92	0.60	0.82	0.66

Note: the reported values are each variable means with standard deviation errors in parenthesis.

Table 2 – Coefficient estimates for the Achievement regression model (equation 4.)

	Austria	Belgium	German	Denmark	Finland	France	Great Britian	Greece	Ireland	Italy	Lux	NLD	Portugal	Spain	Sweden
Highest parental education	2.193 (0.746)**	5.509 (0.443)**	4.117 (0.458)**	5.127 (0.617)**	3.646 (0.402)**	4.438 (0.474)**	5.181 (0.489)**	3.604 (0.495)**	4.711 (0.639)**	2.548 (0.461)**	2.927 (0.323)**	4.221 (0.629)**	1.524 (0.294)**	3.162 (0.334)**	2.779 (0.546)**
Gender	-16.035 (3.880)**	-11.824 (3.076)**	-18.229 (3.237)**	-16.173 (3.039)**	-14.507 (2.129)**	-12.280 (3.712)**	-8.241 (3.332)*	-20.176 (3.205)**	-14.461 (3.042)**	-18.005 (4.481)**	-25.836 (2.937)**	-6.542 (3.265)*	-9.906 (2.838)**	-8.861 (2.700)**	-13.227 (2.807)**
Citizen	31.839 (5.218)**	54.908 (4.966)**	15.186 (6.440)*	30.283 (7.017)**	39.336 (6.378)**	25.300 (10.412)*	1.310 (5.648)	25.879 (5.429)**	-4.687 (5.169)	19.715 (7.988)*	19.896 (3.367)**	32.881 (6.918)**	25.974 (12.181)*	21.472 (8.905)*	49.205 (6.038)**
Work-mother	2.201 (3.015)	5.060 (2.438)*	-4.835 (3.955)	2.197 (3.708)	11.285 (2.095)**	3.797 (3.157)	-7.344 (2.759)**	15.395 (3.159)**	-1.958 (2.812)	15.227 (2.806)**	-3.703 (3.639)	-13.773 (3.190)**	3.267 (3.426)	0.821 (2.292)	5.332 (2.796)
Work-father	12.545 (3.935)**	34.995 (3.732)**	19.590 (3.407)**	18.143 (3.739)**	10.173 (3.562)**	14.134 (3.710)**	15.460 (4.455)**	7.596 (3.310)*	18.530 (3.757)**	17.384 (3.089)**	16.745 (5.054)**	6.579 (4.634)	24.425 (4.122)**	11.502 (3.099)**	10.299 (4.266)*
Books	24.702 (1.382)**	16.249 (0.956)**	23.429 (1.345)**	16.757 (1.085)**	18.255 (0.947)**	21.842 (1.235)**	21.185 (1.113)**	17.672 (1.357)**	17.289 (1.143)**	19.361 (1.028)**	18.739 (1.016)**	20.487 (1.206)**	22.082 (1.220)**	22.202 (1.042)**	22.056 (1.062)**
Family	6.332 (3.573)	24.216 (2.360)**	-1.378 (4.037)	16.820 (2.944)**	0.291 (2.881)	7.778 (3.181)*	7.938 (3.131)*	21.264 (3.943)**	23.686 (3.457)**	16.213 (2.614)**	14.309** (3.549)	19.611 (3.449)**	7.913 (2.880)**	5.278 (2.721)	17.278 (3.392)**
Constant	360.239 (12.196)**	320.598 (8.649)**	360.393 (9.307)**	336.366 (9.478)**	383.225 (9.411)**	352.652 (14.860)**	359.715 (9.915)**	300.376 (9.650)**	365.905 (9.900)**	329.149 (12.134)**	367.311 (6.671)**	379.145 (10.703)**	339.470 (16.240)**	341.340 (10.928)**	328.103 (11.202)**
Number of observations	4187	7521	3755	3586	5378	3658	7995	3947	3445	10793	3074	3460	4138	9625	4033
R-squared	0.21	0.20	0.23	0.18	0.14	0.21	0.20	0.18	0.18	0.16	0.222	0.22	0.22	0.20	0.20

Note: standard errors in parenthesis
Regressions weighted by students' sampling probabilities.

- significant at 5%; ** significant at 1%

Table 3 – Concentration Index based upon socioeconomic ranking

Country	***CI***
Austria	0.0197 (0.0024)
Belgium	0.0285 (0.0017)
Denmark	0.0263 (0.0020)
Finland	0.0168 (0.0013)
France	0.0275 (0.0021)
Germany	0.0382 (0.0023)
Great Britain	0.0294 (0.0020)
Greece	0.0302 (0.0027)
Ireland	0.0232 (0.0018)
Italy	0.0247 (0.0021)
Luxemburg	0.0271 (0.0016)
Netherlands	0.0209 (0.0023)
Portugal	0.0292 (0.0022)
Spain	0.0252 (0.0017)
Sweden	0.0154 (0.0016)

Note: in parenthesis are exhibited the values for standard errors

Regressions weighted by students' sampling probabilities.

Table 4– % contribution of the different determinants to *CI*.

Country	*Pared*	*Gender*	*Citizen*	Full – worker mother	Full – worker father	Books	Family
Austria	0.3182	-0.0103	0.0146	0.0051	0.0151	0.6774	0.0002
Belgium	0.5346	0.0098	0.0090	0.0123	0.0642	0.2704	0.0141
Denmark	0.5021	0.0230	-0.0060	0.0036	0.0261	0.3154	0.0238
Finland	0.5132	0.0164	-0.0196	0.0441	0.0252	0.3715	0.0007
France	0.4681	0.01395	0.0044	0.0083	0.0274	0.4504	0.0072
Germany	0.4082	0.0086	0.0171	-0.0043	0.0270	0.4077	0.0005
Great Britain	0.5136	0.0014	-0.0006	-0.0159	0.0183	0.4538	0.0128
Greece	0.5117	0.0302	-0.0197	0.0624	0.0112	0.3230	0.0169
Ireland	0.5626	0.0162	0.0054	-0.0079	0.0432	0.3896	0.0286
Italy	0.4187	0.0206	-0.0055	0.0701	0.0312	0.4579	-0.0031
Luxemburg	0.5093	0.0038	0.0436	0.0030	0.0160	0.4129	-0.0008
Netherlands	0.4973	0.0073	-0.0016	-0.0166	0.0065	0.4920	0.0070
Portugal	0.3616	0.0234	-0.0034	0.0139	0.0344	0.5529	-0.0048
Spain	0.5091	0.0102	-0.0064	0.0033	0.0089	0.4656	-0.0018
Sweden	0.5015	0.0123	-0.0060	0.0113	0.0184	0.4996	0.0242

Table 5 – Decomposition of socioeconomic status contribution to socioeconomic related inequality in mathematic achievement

Country	*Cpared*	*η pared*
Austria	0.1108	0.0566
Belgium	0.1085	0.1408
Denmark	0.0915	0.1445
Finland	0.0926	0.0933
France	0.1240	0.1037
German	0.1461	0.1068
Great- Britain	0.1146	0.1311
Greece	0.1461	0.1058
Ireland	0.1115	0.1171
Italy	0.1510	0.0685
Luxemburg	0.1733	0.0797
Netherlands	0.1035	0.1004
Portugal	0.3498	0.0302
Spain	0.1774	0.0724
Sweden	0.1048	0.0735

Table 6 – Relative excess inequality and elasticity (vs. Sweden) of socioeconomic status per country

Relative to Sweden		
Country	Vcpared	V η pared
Austria	0.0558	-0.2302
Belgium	0.0330	0.9144
Denmark	-0.1257	0.9647
Finland	-0.1159	0.2700
France	0.1775	0.4099
German	0.3884	0.4520
Great- Britain	0.0896	0.7834
Greece	0.3995	0.4384
Ireland	0.0623	0.5931
Italy	0.4398	-0.0686
Luxemburg	0.6513	0.0834
Netherlands	-0.0185	0.3649
Portugal	2.3429	-0.5890
Spain	0.6959	-0.0152
Sweden	0	0

Table 7 - Decomposition of possession of books contribution to socioeconomic related inequality in mathematics achievement

Country	*Cbooks*	η *Books*
Austria	0.092	0.169
Belgium	0.075	0.102
Denmark	0.072	0.116
Finland	0.053	0.118
France	0.086	0.143
German	0.091	0.169
Great Britain	0.090	0 147
Greece	0.076	0.128
Ireland	0.079	0.115
Italy	0.081	0.139
Luxemburg	0.083	0.134
Netherlands	0.080	0.128
Portugal	0.111	0.145
Spain	0.086	0.144
Sweden	0.045	0.169

Table 8– Relative excess inequality and elasticity (vs. Sweden) of possession of books per country

Country	Vcbooks	Vηbooks
Austria	0.7495	-0.2243
Belgium	0.6356	-0.3950
Denmark	0.5696	-0.3158
Finland	0.1715	-0.3020
France	0.8716	-0.1519
German	0.9983	0.0090
Great Britain	0.9343	-0.1323
Greece	0.6326	-0.2406
Ireland	0.6879	-0.3227
Italy	0.7670	-0.1758
Luxemburg	0.8093	-0.2075
Netherlands	0.7614	-0.2432
Portugal	1.4330	-0.1432
Spain	0.5181	-0.1459
Sweden	0	0