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Regional school choice and school selectivity: how do they relate to student performance? Evidence from PISA 2003

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Abstract

School choice and accountability have become popular educational policies in the US and the UK. In Europe, such policies are less often applied. Moreover, even when school choice exists, information on school quality is rarely provided, leading to pupil sorting by observable characteristics. In this paper, we estimate how the regional intensity of school choice and the regional percentage of selective schools relate to student test scores in math, reading and science at age 15. We estimate an education production function exploiting regional aggregation in 8 European countries to reduce potential endogeneity bias. We find that both the regional intensity of school choice and that of school selectivity are correlated with significantly higher student test scores.

JEL classification: I20, I28

Keywords: School choice, pupil performance, education, school selectivity

1. Introduction

One of the first empirical studies of the factors that influence student's scholastic results was the 'Coleman Report' (Coleman et al.1966). The authors found that, in the US, more financial resources in schools were not significantly related to higher student test scores. To the contrary, the most important predictor of test scores was the socio-economic background of pupils. Since then, international research has not produced clear-cut evidence on the effect of additional funding on student performance (Hanushek, 2003). As a result, attention shifted to other factors that could have a significant impact on student test scores. In particular, authors turned to the incentives to teacher and student effort that resulted from the institutional settings of educational systems (Hanushek, 1997; Woessmann, 2003). This paper fits into the latter category as we study how the regional practice of school choice and school selectivity relate to student test scores.

In the United States as well as in the United Kingdom, allowing free school choice has become a popular guideline of educational policy. The idea behind this type of policy is that the possibility of school choice combined with information on school quality will result in competition between schools. This is predicted to create incentives for schools to perform better as they try to attract more pupils and/or more funding. In short, schools are expected to increase their effort in providing high quality education.

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However, there are severe impediments to the realisation of this prediction following the introduction of school choice. First of all, there is the absence of sanctions for low-performing schools. Incentives to productivity in a classical market are ensured by inefficient firms leaving the market. But low-performing schools are rarely closed since they are public institutions. As a consequence, if school choice is to deliver incentives to effort for low-performing schools, sanctions and/or help for quality improvement should be provided by the educational authority.

A further obstacle to the functioning of school competition as an incentive for school effort could be the unavailability of information on school performance. Information on school performance is a crucial requirement for school competition to be effective in increasing school effort. As parents and institutions are able to identify the low-performing schools, these can be sanctioned (or helped) accordingly. If information on school performance is not (publicly) available, as is often the case in Europe, school choice may foster segregation and selectivity of schools. In effect, in the absence of objective information on school quality, parents will tend to choose their children's school based on observed quality of the peer pupils, contributing to sorting of pupils by socio-economic status and abilities at entry. In such a context, schools moreover have an incentive to select pupils according to performance. In effect, admitting only better performing pupils ensures the schools a good reputation at low costs, because lower performing pupils do not need to be taken care off.

The sorting of pupils that results from school selectivity and parents' peer-based school choice may have several effects on pupil performance. On the one hand, pupil sorting generates specific peer effects. Theoretical models predict that low performing pupils will suffer and high performing pupils will benefit from being grouped according to ability. However the evidence on peer effects in the empirical literature is mixed (see e.g. Levin 2001, Rangvid 2003). Low-performing pupils may face lower teacher expectations and develop less confidence in their learning skills as they and their teachers are aware of being classified in a low ability school/group. But teaching methods and materials may be better adapted to match the ability of the group.

On the other hand, selectivity of secondary schools may provide an incentive to effort in primary school pupils similar to that of an external evaluation standard (see e.g. Bishop and Mane 2001). That is, pupils may increase effort in order to have better chances of being admitted to selective secondary schools. When the percentage of selective schools increases and thereby the chance of admittance to a secondary school with high ability peer pupils, pupils will have an incentive to increase effort.

Most of the existing empirical research on school competition has been done on United States data. A large share of this research focuses on evaluating the impact of the introduction of vouchers and charter schools on student performance (see e.g. Ladd, 2002, Holmes et al., 2003, or Neal, 2002). A more limited strand of the literature focuses on general indicators of school choice and competition (see e.g. Hoxby, 2003). In their reviews of the literature, Belfield and Levin (2002) as well as Hoxby (2002) come to the conclusion that a majority of studies finds significant positive effects of the level of school competition on student performance. However, Belfield and Levin (2002) also remind us that these effects are too small to allow any policy recommendations.

The availability of external information on school performance seems to lead to achievement growth in the United States, especially when sanctions apply for low-performing schools (Carnoy and Loeb 2003, West and Peterson 2005, Hanushek and

Raymond 2004). The effect of school accountability on low-performing students' achievement is not clear. Some studies find a particularly important positive impact on low-performing and disfavoured students (e.g. West and Peterson 2005), others find a positive but less important impact on low than on better-performing students' achievement (e.g. Hanushek and Raymond 2004). Measures of school accountability are quite diverse in the literature, making it difficult to compare the size of the effects.

In most European states, education is largely funded and provided by the public sector. Uncertainty as to political impact of competition between schools and the outcomes of external school evaluations are important sources of reluctance against such policies. As a result, evidence on the level of school competition outside the United States is scarce and heterogeneous. Recent reviews can be found in Gibbons et al. (2006) or Burgess and Slater (2006). To sum up, one can say that most evidence mainly comes from only 4 countries (the United Kingdom, Denmark, Sweden and Israel), that the studies are hardly comparable and that results are mixed. For the UK, Levacic (2004) finds a positive effect of the perceived level of school competition by school directors on test scores and Bradley et al. (2000) find that schools that are under more competition are also more efficient. But Burgess and Slater (2006) and Gibbons et al. (2006), both exploiting the geographical boundaries of the educational market as a source of exogenous variation in school choice in the UK, find no significant effect of increased school choice on pupil performance. In Sweden, using the introduction of a generalised voucher system, Sandström and Bergström (2002) find a small but significant positive impact on test scores of increased school choice. To the contrary, in Denmark, Andersen (2005) finds no effect of the relatively more important competition in private versus public schools on student performance. Lavy (2005), using a policy change to identify the effect of increased school competition in Israel, concludes to a lower dropout rate and higher graduation rates for schools subject to higher levels of competition.

In this paper, we provide descriptive evidence as to the relation between school choice, school selectivity and student performance in a set of countries where little research exists on this topic. Unfortunately we cannot go as far as to identify causal effects but we do try to take the most out of the available data to develop insights into the relation between school choice and selectivity with student performance in countries that do not yet have sufficiently good data to go further. To this purpose, we use responses to the PISA 2003 questionnaires in 8 different countries. We have information as to whether schools give high priority to student records for admission and we know from the pupil's questionnaire whether the pupil claims to attend its school because of its good reputation rather than the distance to the parents' home or the religious character of the school.

We estimate an education production function on the pooled data for these 8 countries to assess the relation between regional school choice and selectivity and student test scores. In a second stage, we discuss possible interpretations of the measured effects and then perform quantile regressions to estimate differences in the effect for low versus better-performing pupils. In section 2 we present the dataset. In section 3, we justify our choice of measures of school choice and selectivity. Section 4 contains the estimation strategy and descriptive statistics of the main explanatory variables. Section 5 is devoted to the interpretation of the results and conclusions follow in section 6.

2. The data

This paper uses cross-section data from the OECD survey conducted in 2003 as part of the Program for International Student Assessment (PISA). The PISA 2003 database contains comparable math, science and reading test scores of a sample of pupils of about 15 years-old (sampled based on birth year) coming from 40 OECD and non-OECD countries. All the students in the sample took a standard reading, math, and/or science test, which provided the test scores. The scores are comparable across countries but not across disciplines. The sampling procedure ensures that schools and pupils inside them are randomly selected and that the sampled set of students is representative of the country's student population. Pupils are nested within schools, potentially attending different grades. For each pupil i trained in school j, the PISA data provides us with a large number of variables characterizing the student, its family and the school it is attending, from which we selected the variables relevant to our analysis. Following a common practice in the literature (Brown, 1991; Vignoles *et al.*, 2000), and in order to ease interpretation of estimates, we use the test scores normalized to mean 500 and variance 100 as a measure of educational output. Five different measures of the obtained test scores (so-called Plausible Values) are provided for each discipline in the dataset. In line with the recommendations of the PISA Manual, estimations are performed separately for each of the Plausible Values and then averaged. We use the student weights to ensure the representativeness of the sample of pupils.

We have used the stratification of the dataset to retrieve in which regions the schools are located. This information is available only for 18 countries which we keep in our dataset. In the remaining countries, either the data is not stratified by regions, or information as to what the criterion for stratification was is not publicly available. Eight out of the obtained sample of 18 countries have a central educational authority. This is the sample we use to perform the estimations and corresponds to 150 regions and 36290 observations after removal of missing observations. The reasons for including only those 8 countries are related to the estimation strategy and are explained in section 4.

3. Measuring school choice and selectivity

We use the pupil questionnaire to retrieve information on school choice. This information will be aggregated at a regional level (see section 4). The pupils are asked whether they "attend their school because it is known to be a good school". If the pupil responded 'yes' then we consider there has been quality-based school choice. The dummy SCHOOLCHOICE then equals one, zero otherwise. One might be concerned that our measure of school choice is based on the pupil's perception and therefore a subjective indicator. However, we have reasons to believe that the pupil's answers do provide a reasonable approximation of effective school choice.

First of all, this question is part of a set of sub questions that propose alternative reasons to attend this particular school. The alternatives are: being in this school because it is close to the pupil's home, because of its program, or for religious reasons. The question as to the school's reputation is therefore clearly referring to academic quality of the school.

Secondly, one might suspect that the pupil could also include in the school's "good" reputation criteria that are not related to the quality of teaching but to their general appreciation of the school. We therefore look at two measures of pupil well being in the school (feeling awkward or lonely in school) and test whether they are related to answering that the attended school is good. There is no significant correlation between feeling awkward or lonely in school and claiming to attend a school because of its reputation. It does therefore not seem to be the case that the well being of the pupil is the basis for claiming to be in a good school.

Thirdly, responding that the school choice was based on reputation is negatively correlated with responding that it was based on vicinity. Pupils that claim to be in their current school because of vicinity are half as likely to claim also quality based school choice than those who did not mention vicinity as a reason for school choice (17.73 versus 32.01 percent). Although these two reasons can clearly be valid simultaneously, vicinity should restrict the possibility of quality based school choice. The descriptive statistics are in line with this intuition.

Fourthly, we expect school choice to be more straightforward in cities, where more than one school may be close to the parents' home. In our data, the percentage of pupils that claim to attend their school because of its reputation increases linearly with city size. Whereas in villages only 11% of the pupils claim to be in their school because of its reputation, 45% do so in large cities of more than a million inhabitants (Table 1). This supports our assumption that our measure of school choice reflects the actual possibilities of quality-based school choice.

Table 1: Percentage of pupils that claim to attend their school because it is know to be a good school by number of books at home, parent education level and city size.

Number of books at home		**Parent education**		**City size**	
Less than 10	24%	None	22%	Less than 3000	11%
11 to 25	24%	ISCED 1	30%	3 to 15 000	20%
26 to 100	24%	ISCED 2	21%	15 to 100 000	26%
101 to 200	26%	ISCED 3B,C	21%	100 000 to 1 million	30%
201 to 500	29%	ISCED 3A-4	25%	More than 1 million	45%
More than 500	32%	ISCED 5B	19%		
		ISCED 5A-6	32%		

Source: PISA 2003 data, OECD.

Furthermore, more educated parents could be more likely to choose schools based on reputation, creating a selection bias among pupils that respond yes to school choice. The data do not point to such an issue. The proportion of pupils that claim to be in their school because of its reputation is similar across parent education levels as well as between families with different numbers of books (see Table 1).

To sum up, our subjective measure of school choice is in line with some basic assumptions we have about school choice. Measured school choice increases with city size and is less frequent among pupils that claim to attend their school because of vicinity. Pupils from different socio-economic backgrounds claim quality-based school choice in a similar proportion, and the alternative reasons for school choice should make clear to the pupil that a 'good school' refers to the quality of the teaching. The information we have on the well being of the pupil in the school is not correlated with claiming to attend a good school.

Finally, the fact that our indicator of school choice is based on the pupil's perception also has an advantage compared to e.g. an institutional indicator. In effect, even when school choice is constrained by law parents may change their place of residence in order to give their children the possibility to attend a better school. To the contrary, even when school choice is fully unconstrained by legislation, there may be other barriers to exerting this choice such as the proximity of schools to the parents' home. By using pupil level information on school choice we avoid these problems of non compliance to the legislation.

The information on school selectivity is taken from the school questionnaire. School directors are asked "how much consideration is given to the following factors when students are admitted to your school?" If the school director answered that a student's academic record (including placement tests) is a prerequisite or a high priority for admittance (rather than considered or not considered at all) the school is considered to be selective and the dummy SCHOOLSELECTS set to one.

4. The estimation strategy

We aggregate the dummy variables SCHOOLCHOICE and SCHOOLSELECTS to regional percentages: the regional percentage of students that claim to be in their school because it is known to be a good school (PERCENTCHOICE) and the regional percentage of schools that claim to admit students based on their academic record (as a high priority or as a prerequisite) PERCENTSELECT. There are two important reasons to do so: the aggregated variables are more meaningful as measures of school incentives and the aggregation is a partial answer to the likely endogeneity problem of school choice and selectivity.

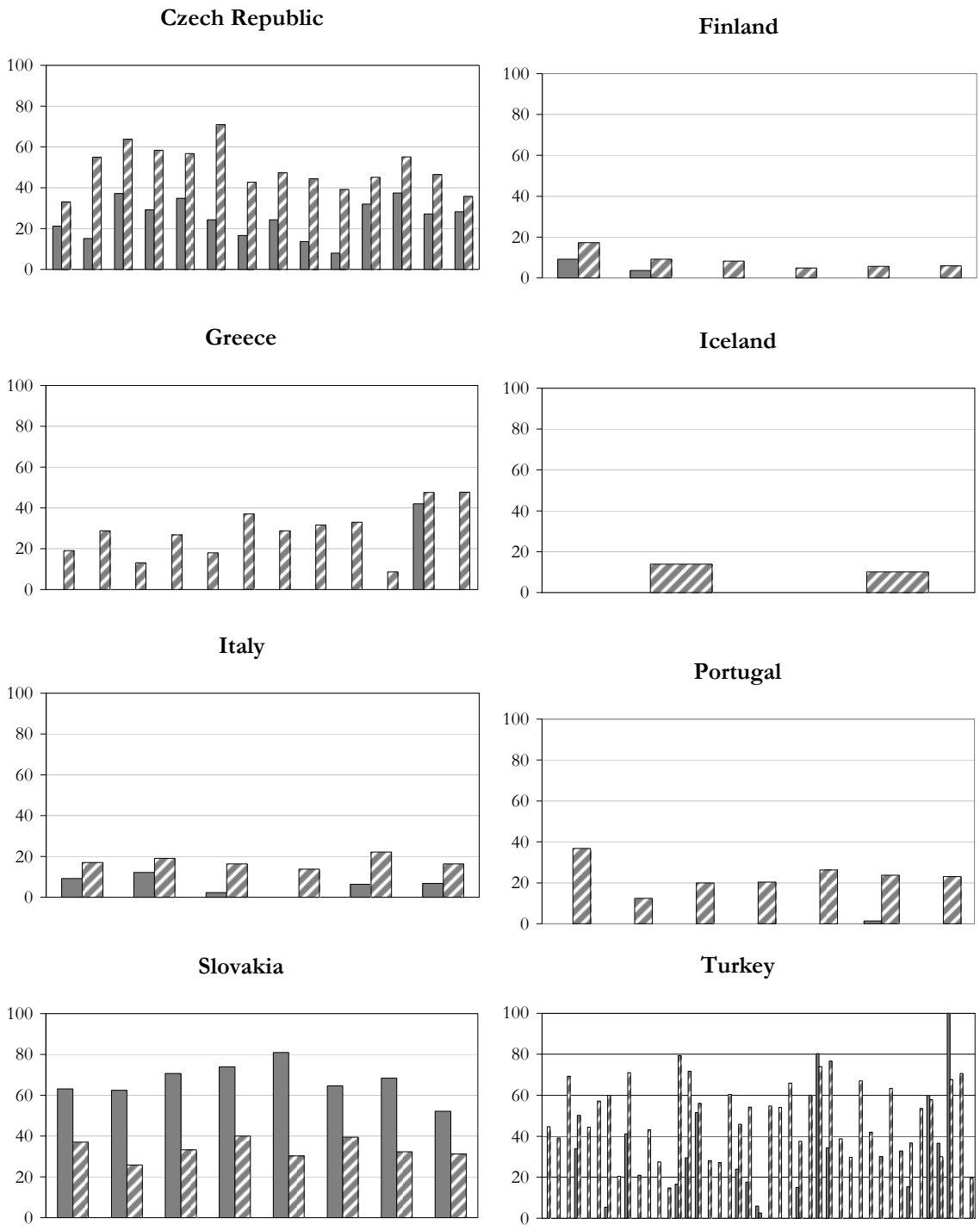
The percentage of pupils that claim to attend their school because it is known to be good is a measure of the intensity of school choice in a given region. A region may present a high degree of school choice for several reasons. The regional intensity of school choice by parents can be a result of legislation (that determines whether they may choose at all) but also of geography (if there are few local schools choice is limited) or variance in school quality (if all schools have the same quality, residence becomes the main criterion). Which explanation for the intensity of school choice is most relevant in a given region is not relevant for our question of interest. Whichever explanation dominates, the relevance of school choice as an incentive for schools to perform better

should increases with the proportion of parents participating and the schools' incentive to perform should be maximal when all parents use quality criterions. The regional intensity of school choice therefore seems a reasonable measure of the incentive to effort provided to schools.

Descriptive statistics of the regional percentage of schools giving a high priority to student records for admittance and the regional percentage of pupils that claim to attend their school because it is known to be a good school are presented in Figure 1. We observe that there is important regional variation in both variables and that our measure of the regional intensity of school choice is compatible with what we know of the national educational systems.[3] For instance, Finland and Iceland allocate pupils to a school in their neighbourhood. Attending another school is an exception in these countries. The percentage of pupils that claim to attend their school because of its reputation is of about 10 percent there (Figure 1). On the other hand, in the Czech Republic and Turkey, parents have free school choice and PERCENTCHOICE is of about 50 percent. Secondly, even when the legal setting allows school choice, choice may be constrained by geographical isolation or limited differences in school quality. Therefore PERCENTCHOICE may be lower than expected from the institutional setting in certain countries. In Italy and Portugal for instance, school choice is free but only about 20 percent of pupils claim to be in their school because it is known to be good.

[3] Source: Eurydice.com

Figure 1: Descriptive statistics PERCENTSELECT and PERCENTCHOICE, by country.
Legend: Stripes = PERCENTCHOICE, Plain= PERCENTSELECT.

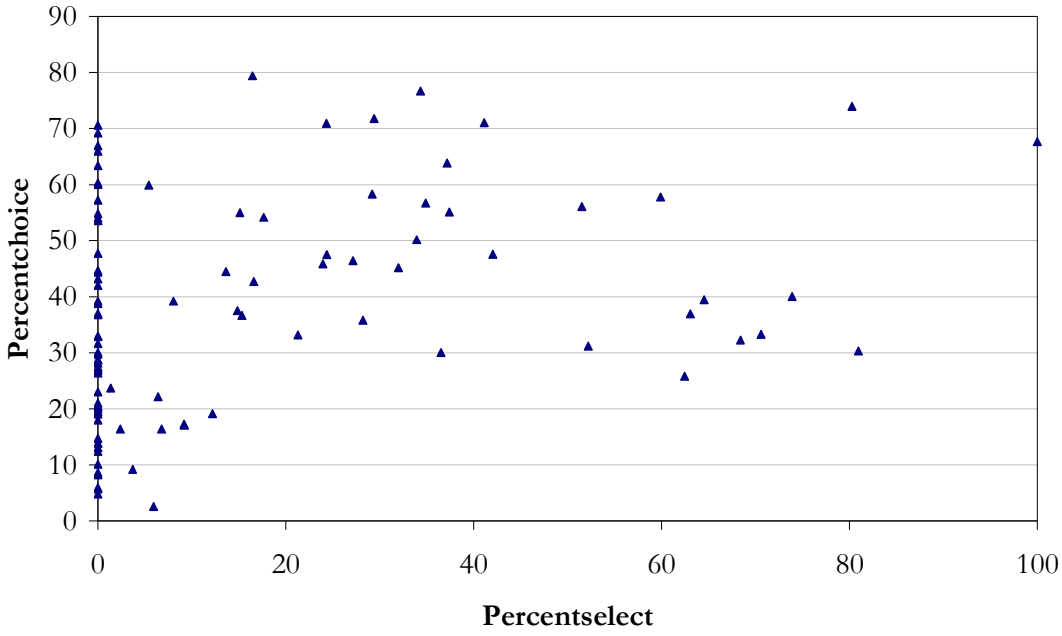


Source: PISA 2003 data, OECD.

Our second main explanatory variable, the percentage of schools that use student academic records as a high priority admittance criterion (or as a requirement) in a given region is a proxy for the intensity of pupil sorting by performance across schools. It is unclear whether pupil sorting by ability has positive or negative aggregate effects on pupil performance. Sorting by ability may have negative effects on low-performing pupils because of negative peer effects, but positive effects on high-performing pupils as they benefit from high-performing peers. Lower teacher expectations and stigmatisation may further lower effort of low-performing pupils. On the other hand, the low-performing pupils may benefit from more adapted teaching methods in a similar peer group. Furthermore, selectivity of secondary schools may provide an incentive to effort in primary school pupils similar to that of an external evaluation standard (see e.g. Bishop and Mane 2001). That is, pupils may increase effort in order to have better chances of being admitted to selective secondary schools. When the percentage of selective schools increases and thereby the chance of admittance to a secondary school with high ability peer pupils, more pupils will have an incentive to increase effort. Which effects dominate is a topic of empirical investigation.

Figure 2 shows a scatter plot of PERCENTSELECT and PERCENTCHOICE. First of all this figure makes clear that in many regions there is no school selectivity at all. Secondly, we observe that the two variables are not strongly correlated.

Figure 2: Scatter plot PERCENTCHOICE – PERCENTSELECT (regional percentages).



Source: PISA 2003 data, OECD.

The second reason why we choose to use regional variables is that both the dummy variables of school selectivity and school choice are potentially subject to both a reverse causality and to an omitted variables problem. Indeed, there may be a problem of reverse causality in the estimation at the school and at the individual level: the observed better school performance may lead more parents to choose a given school.

And at the individual pupil level, parents of better pupils may more often pay care to the choice of high quality school.

Furthermore it is likely that schools that choose to select pupils by ability at the entry have unobserved characteristics that relate to student performance and that

parents that choose a school on the basis of reputation or program might be more educated and/or motivated as they want to provide their children with best possible learning environment. The omission of these variables may bias our estimates.

Regional aggregation is a way to limit the type of endogeneity biases mentioned above. In effect, bias due to unobserved school and parent characteristics is no longer an issue as we measure choice and selectivity at the regional level. We interpret the regional proportion of schools selecting pupils at entry and the proportion of pupils claiming to attend schools because of their reputation as proxies for the regional preference for school choice and school selectivity. Such preference may emerge from the institutional setting or regional common practice. The absence of information on schools' actual performance is for instance thought to be an important determinant of the presence of school admittance criteria. The impact of the regional preference for or common practice of school choice is precisely what we want to estimate.

We include several regional characteristics we think could be related to school choice such as the average socio-economic status of parents in the region, the regional unemployment rate (as a proxy for economic welfare) and average class size (as a proxy for educational budget). The idea is that using a specification with regional variables, the coefficients of our main explanatory variables do not merely capture regional fixed effects but more specifically variance in test scores related to the included variables.

However, unobserved characteristics of the regions may still bias our results. The intensity of school choice and selectivity may e.g. be related to unobserved institutional characteristics such as the quality of educational policy that affects both test scores and the amount of school choice thereby biasing our estimates. The PISA data are repeated cross-sections, making it impossible to apply fixed effects panel estimations to control for unobserved regional characteristics. Furthermore, the information as to the regional location of schools is only available from PISA 2003, preventing the use of pseudo-panel techniques to remove the regional fixed effects.

As a consequence, we include only countries that have a central authority for educational policy. The idea is to ensure that the country fixed effects will capture an important share of the unobserved institutional effects. Indeed, the country fixed effects will only capture unobserved characteristics that are the same for all individuals in the country. Such fixed effects are thus expected to play their role better in a centralised system, where all pupils are affected by similar country characteristics. In a regional system, we expect a lot less common national unobserved characteristics and coefficients should rather be biased by regional unobserved characteristics. In case of a regional educational system, one would prefer to use regional fixed effects, but this is not possible as our variables of interest are regional. We thus use only countries with a centralised educational system where the country dummies are most reliable. Federal states such as Belgium, Brazil, Canada, Germany, Switzerland, Spain and Australia are therefore excluded. We also exclude the United Kingdom, where educational policy is managed by the regional authorities and Mexico which decentralised its educational

system in 1992.[4] This leaves 8 countries which all have a central educational authority. The Czech Republic is in the process of a decentralisation since 2001 but we chose to keep it as the change is very recent and the country dummy should still capture most of the national characteristics in 2003.

4.1. The education production function

We estimate an education production function. It is defined as an efficient technology (Cooper and John, 1997) turning a vector of educational inputs X into a vector of output Y:

$$Y = f(X) \quad (1)$$

In Equation (1) above, X may include such inputs as a child's abilities, his/her family background and/or educational resources, and where Y may be a set of test scores or exam results. In theoretical works, the education production function f may appear as a "black box", with its the functional form left unspecified. Applied analyses, however, generally rely on a classical regression approach, which assumes a linear (or log-linear) shape for *f*.

Using a mixed model allows us to take into account the hierarchically correlated structure of the test score variance. Indeed students are grouped in schools that function in a particular regional and/or national setting. It is to be expected that test scores of students in a same school are correlated with each other as a result of unobserved school characteristics. In a similar way, average achievement of pupils in a same region could be correlated as they are submitted to a common political and economic environment.

Such models, also known as multilevel models (Yang, Goldstein et al, 2002), are frequently used in estimating education production functions since samples of pupils are generally nested inside classrooms, schools and regions. We include country dummies to capture unobserved country effects, and school and regional effects that are assumed to be drawn from a normal distribution. The unobserved regional effects are assumed to be 'nested' because they may be correlated inside a same country.

Mixed models are estimated using the Maximum Likelihood technique imposing the particular hierarchical structure to the variance-covariance matrix. Singer (1998) provides a detailed summary of this estimation procedure.

4.2. Control variables

Besides our variables of interest, Table 2 gives summary statistics of our dependant and explanatory variables. The latter were chosen in order to stay as close as possible to the conceptual framework sketched in the theoretical literature (e.g., Creemer, 1994; Scheerens, 1997; Creemers et al., 2000). A small number of factors are herein put forward to explain pupils' success: their initial aptitudes, perseverance or effort, the opportunities offered to them, and the quality of instruction.

[4] Information as to the degree of centralisation of the education systems was taken from the UNESCO (IBE) website.

Table 2: Descriptive statistics

	Mean	**Std Dev**
Dependant variables		
Maths test scores	500	100
Reading test scores	500	100
Science test scores	500	100
Explanatory variables		
Percentchoice	0,25	0,15
Percentselect	0,15	0,23
Mean socio-eco status region	48,21	4,91
Mean class size region	12,46	4,74
Unemployment rate region	7,70	4,60
Age	15,77	0,29
Boy	0,5	0,5
Number of books at home	3,45	1,35
Non-nuclear family	0,25	0,43
Home educational resources	0	1
Parent education	3,99	1,67
City size	2,99	0,96
Grade	9,73	0,61
School educational material	0	1
Centralbudget	0,32	0,47
Centralcontent	0,39	0,49
Centralhiring	0,57	0,49
Centralwage	0,82	0,38
Mean nb. of books at home (school level)	3,45	0,70
Mean parent education school	3,99	0,96
Vocational school	0,27	0,45
Observations	**36 290**	

Source: PISA 2003 data, OECD.

Relying on an extensive literature (e.g. Ehrenberg, Goldhaber et al 1995; McNabb, Sarmistha et al, 2002), we control for gender (the dummy BOY) and AGE as observable individual characteristics.

We then chose relevant measures and/or proxies for the two last groups of factors listed above, starting with the opportunities offered to pupils. These are represented firstly by the size of the city the pupil lives in (CITY SIZE), as an index from 1 (village of less than 3000 inhabitants) to 6 (city of more than a million inhabitants). A larger city may e.g. provide more social services, a better library or simply have access to better teaching materials. Another very important determinant of overall opportunities available is the pupil's family background. This includes information on whether the pupil lives with both parents[5] (NON-NUCLEAR FAMILY dummy), the level of education of the highest educated parent according to the ISCED classification (PARENT EDUCATION). We also included an index (1 - 6) for the number of books in the house as estimated by the student (NUMBER OF BOOKS), and the relative availability of learning resources at home (HOME EDUC. RESOURCES[6]). Several studies (e.g. Murnane et al, 1981) suggest that the number of books at home is a fairly reliable proxy to describe a family's inclination towards learning. Home educational resources is an index based on the availability at home of a desk to study at, a quiet place to study, a calculator and a dictionary as well as books useful for homework. For more details on the construction if this index please refer to OECD (2003). As regional control variables, we include the unemployment rate (based on the PISA sample), and the average level of the socio-economic index of occupational status.

The quality of instruction was captured by several school variables. We first introduce information on the school's educational resources (SCHOOL EDUC. MATERIAL) as an index based on the availability of books, computers, software, calculators, library materials, audio-visual and laboratory equipment. Secondly we include information on whether the pupil attends a vocational or general type of secondary school (VOCED) and the attended GRADE. We include class size only as a regional average because this information is missing for a large number of schools.

Furthermore, many studies (Hanushek 1997, 2003; Hoxby, 2000) underline that the effect of material resources is not systematic, and suggest that institutional factors and incentives structures may have a strong effect via motivation and effort. For instance Woessmann (2000), using country-level data from PISA, found that students' performance could stem primarily from institutional and school organizational characteristics, such as autonomy in school management decisions. To take into account this possibility, we added 4 school-level institutional indicators the degree of centralization of the decisions made on teacher hiring, wage increases, the size of the school budget, and defining course contents, as well as two measures of peer quality at the school level (the average number of books at home and parent education by school).

4.3. The estimated specifications

This section presents the different estimated specifications of the education production function. In a first specification, we estimate the effect of

5 The NON-NUCLEAR FAMILY dummy equals one if the student does not live with a mother and a father.

6 HEDRES in the PISA terminology, it is based on the availability of a dictionary, a quiet place to study, a desk to study, textbooks and calculator at home.

PERCENTCHOICE including only country dummies Dk, regional and individual control variables:

$$SCORE_{isjk} = \beta_1.PERCENTCHOICE_{jk} + \sum \alpha.X_{isjk} + \sum_{k=1}^{N_k} D_k + \gamma_{jk} + \lambda_{sk} + \varepsilon_{isjk} \quad (1)$$

where for student i in school s in region j in country k, SCORE is the test score in a given discipline, γ and λ ,the random regional and school effects, assumed to be drawn from a normal distribution and regions nested within their country and εijk is the residual term, also assumed to be normally distributed.

In specification 1, the coefficient of PERCENTCHOICE measures the total effect of school choice. It includes the impact of the potential increase in effort and/or discouragement resulting from school competition, and the impact of pupil sorting on test scores.

In a second step, we then include PERCENTSELECT and two measures of school peer effects (the average number of books at home and parent education by school). The aim is to disentangle the effect of pupil sorting according to performance and related peer effects from the residual effect of school choice. This yields specification 2:

$$\begin{aligned} SCORE_{ijk} &= \beta_1.PERCENTCHOICE + \beta_2.PERCENTSELECT \\ &+ \beta_3.NBBOOKSSCHOOL + \beta_4.EDUCPARENTSSCHOOL + \sum \alpha.X_{ijk} + \\ &\sum_{k=1}^{N_k} D_k + \gamma_{jk} + \lambda_{sk} + \varepsilon_{ijk} \end{aligned} \quad (2)$$

In this specification we interpret the coefficient of PERCENTCHOICE as the correlation between test scores and school effort related to school choice. The coefficient of PERCENTSELECT is interpreted as a measure of the correlation between test scores and school selectivity net of peer effects i.e. as variation in test scores related to pupil motivation to enter a selective secondary school, and to specific teaching methods.

Low versus high-performing pupils might react differently to the presence of school choice and sorting. As mentioned in the introduction, once we control for peer effects, pupil sorting may affect test scores through several other channels such as adapted teaching methods, teacher and pupil expectations, and an incentive to pupil effort due to selection at the entry of secondary school. Low performing pupils could face lower teacher expectations and decrease effort, while benefiting from adapted teaching methods. High and average performing students on the other hand may be motivated by the possibility to enter a selective secondary school and benefit from higher teacher expectations and high quality teaching.

Besides increasing the degree of pupil sorting, school choice might lead to higher standards of performance and school effort. These may have either positive or negative

impacts on student results, as schools put more effort into different types of pupils and increasing standards may discourage low performing pupils while pushing average performing students to more effort (e.g. Betts and Grogger 2003)..

In order to test whether school choice and pupil sorting affect low versus high performing pupils differently in our model, we apply the quantile regression procedure to specification 2. This allows us to compare the effect of PERCENTCHOICE and PERCENTSELECT across quantiles of pupil performance. Technically, quantile regressions consist of a generalization of the conditional median estimation or least absolute deviation (Koenker, 2000). It was "rediscovered", developed and introduced in the economic literature by Koenker & Bassett (1978). It is a method of estimation of conditional quantile functions for any quantile θ of the dependent variable. When estimating quantiles, absolute deviations are given positive and negative weights, in such a way that a fraction θ of the observations will lie below the fitted line while a fraction (1 –θ) will lie above it.

The q^{th} quantile coefficients are obtained as a solution to the expression below:

$$(3) \qquad Min_{\beta \in R^k} \left\{ \sum_{i:Score \geq x_i.\beta} \theta \left| Y_i - x_i.\beta_\theta \right| + \sum_{i:Score < x_i.\beta} (1-\theta) \left| Y_i - x_i.\beta_\theta \right| \right\}$$

where Y stands for test scores. We estimate equation 3 for 5 different quantiles (percentiles 0.10, 0.25, 0.50, 0.75 and 0.90) so as to obtain our set of coefficients across levels of pupil performance. We do not use a mixed model to perform the quantile regression. However, country fixed effects are included and we use the same student weights as in the other specifications.

5. Results

Table 3 gives the parameter and standard deviation estimates of specification 1 for mathematics, reading and science test scores respectively. Recall from Section 2 that test scores are standardised at mean 500 and standard deviation 100 for all countries. This means we can interpret the coefficients as percentages of standard deviation in student test scores. The effect of an increase of one standard deviation of PERCENTCHOICE is computed as the coefficient in Table 3 times the standard deviation of PERCENTCHOICE found in Table 1 (0.15).

Table 3: Estimates specification 1, Dependant variable: test scores in Maths, Reading and Science.

	Maths			**Read**			**Science**		
Effect	Coeff.		StdErr	Coeff.		StdErr	Coeff.		StdErr
Intercept	47,36		44,28	162,43	***	41,54	70,07		40,58
Percentchoice	83,83	***	29,00	83,83	***	26,13	82,80	***	25,44
Socio eco status region	-0,52		0,92	-0,69		0,83	-0,76		0,81
Class size region	-1,83	***	0,67	-1,28	**	0,60	-1,40	**	0,59
Unemployment rate region	-2,02	**	0,89	-1,84	**	0,81	-1,66	*	0,78
Boy	24,43	***	0,81	-28,15	***	0,83	2,64	***	0,82
Age	2,29		1,39	-2,47		1,43	6,93	*	1,41
Number of books at home	12,21	***	0,34	9,31	***	0,35	11,06	***	0,35
Non-nuclear family	-7,60	***	0,86	-7,50	***	0,88	-2,87	*	0,87
Home educ Resources	7,94	***	0,38	8,43	***	0,39	7,38	***	0,39
Parents' education	3,15	***	0,26	2,99	***	0,26	3,46	***	0,26
City size	7,90	***	0,70	9,43	***	0,71	6,89	***	0,70
Grade	31,34	***	0,77	31,28	***	0,79	29,65	***	0,78
School educ. Material	3,67	***	0,70	3,27	***	0,71	3,32	***	0,71
Centralbudget	8,43	***	1,55	5,37	**	1,58	6,28	***	1,56
Centralcontent	-1,88		1,47	-1,77		1,50	0,28		1,48
Centralhiring	-4,33	*	2,42	-2,51		2,48	-3,81		2,45
Centralwage	-2,51		2,57	-0,80		2,64	-2,29		2,60
Vocational school	-41,98	***	1,41	-42,53	***	1,45	-41,63	***	1,43
Country dummies	yes			yes			yes		

,,*** stand for significance at the 10%, 5% and 1% level of confidence respectively.*
Number of observations: 36 290

Including only PERCENTCHOICE (specification 1) yields a significantly positive correlation with test scores in all disciplines. Each standard deviation increase in the regional intensity of school choice is related to between 12,42[7] (Science) and 12,57 (Maths) higher test score points. Our finding that the percentage of school choice has a small significant positive correlation to student performance is in line with results on school choice from the US mentioned in the introduction.

Individual and family characteristics have a significant effect on test scores in line with the literature. In particular, the number of books at home plays a significant role

[7] 83,83*0.15

for scholar achievement. This is a common finding when estimating education production functions. The number of books at home is thought to capture the attitude of parents towards learning. Parents' education and living with both parents are also significantly related to test scores. The case of gender is interesting, since it shows that female students can expect lower scores in mathematics, but higher scores in reading. This result is similar to what is generally observed in the literature (e.g., Ehrenberg, Goldhaber et al., 1995). Possibly, innate differences in ways of assimilating maths and reading between boys and girls and/or unconscious different expectations from each gender in each discipline by teachers may yield this gender gap. As expected, attending different grades has a very significant impact on test scores in all disciplines. Attending one grade higher is related to about 26 points higher test scores. Sufficient availability of educational material in a school has a small but significantly positive effect on student performance. School educational material measures the sufficient availability of a library, software and laboratory equipment which are very specific material resources and they are measured in terms of need rather than mere quantity. This could explain why this material resources variable has a significant effect contrary to what is found in most estimations of education production functions. The coefficients of the school autonomy variables are not significantly different from zero with the exception of the centralisation of school budget. Attending a vocational track is related to on average about 42 points lower test scores (i.e. 42 percent of a standard deviation in test scores) in all three disciplines.

The results of specification 2 are presented in Table 4. When the measures of school peer quality and the regional intensity of school selectivity (PERCENTSELECT) are included, the coefficient of PERCENTCHOICE is reduced by about 25% in all three disciplines (to between 9,98 and 9,34 test scores points). The coefficient of PERCENTCHOICE now measures the correlation between school choice and test scores given pupil sorting and peer effects. Theoretical arguments suggest it includes the correlation between test scores and increased school effort induced by school choice.

The coefficients of regional school selectivity PERCENTSELECT and of the measures of peer quality in the school are highly significant and positive. A one standard deviation increase in PERCENTSELECT is related to between 18,12 (Maths) and 16,12 (Science) percent of a standard deviation higher test scores[8]. The average level of parent education in the school and the average number of books at home of peer pupils are also positively correlated with test scores. Whereas higher average peer quality is positively correlated with a pupil's test scores in line with our expectations, the positive coefficient on PERCENTSELECT is in conflict with the hypothesis that pupil sorting may be harmful. As we have mentioned in section 4, we expect pupil sorting into schools to affect test scores through several channels. Controlling for peer effects, the coefficient of PERCENTSELECT should measure the correlation between test scores and the remaining potential effects of school selectivity such as those related to specific teaching methods, teacher expectations and the incentive related to selection at the start of secondary school on pupil effort at the end of primary school. We conclude from the results that the positive effects of school selectivity (related to e.g. incentive to effort at the end of primary school or benefits of adapted teaching methods) seem to dominate the negative ones (related to e.g. lower teacher expectations in non selective schools).

[8] The effect of an increase of one standard deviation of PERCENTSELECT: coefficient in Table 2 times the std deviation of PERCENTSELECT (0.23)

Table 4: Estimates specification 2, Dependant variable: test scores in Maths, Reading and Science.

	Maths			**Read**			**Science**		
Effect	Coeff.		StdErr	Coeff.		StdErr	Coeff.		StdErr
Intercept	42,64		36,67	158,13	***	34,80	30,58		33,92
Percentchoice	62,24	***	23,35	66,54	***	20,77	64,99	***	20,07
Percentselect	78,77	***	17,76	70,20	***	16,07	70,08	***	15,55
Socio eco status region	-2,46	***	0,72	-2,49	***	0,64	-2,40	***	0,62
Class size region	-0,66		0,51	-0,25		0,46	-0,32		0,44
Unemployment rate region	-0,80		0,67	-0,59		0,61	-0,28		0,59
Boy	24,30	***	0,78	-28,29	***	0,81	2,88	***	0,80
Age	0,84		1,35	-3,79	**	1,40	3,83	**	1,38
Number of books at home	9,30	***	0,34	6,37	***	0,35	8,13	**	0,35
Non-nuclear family	-7,00	***	0,83	-6,88	***	0,86	-2,06		0,85
Home educ Resources	7,07	***	0,37	7,61	***	0,38	6,37	***	0,38
Parents' education	1,07	***	0,26	1,07	***	0,26	1,58	***	0,26
City size	-2,47	***	0,71	-0,17		0,72	-2,49	***	0,71
Grade	27,09	***	0,76	26,94	***	0,78	25,37	***	0,77
School educ. Material	2,56	***	0,67	2,20	***	0,68	2,30	***	0,67
Centralbudget	7,13	***	1,48	4,41	**	1,51	4,94	***	1,48
Centralcontent	-1,99		1,41	-2,08		1,44	-0,45		1,42
Centralhiring	3,32		2,33	5,02	*	2,39	3,35		2,35
Centralwage	4,83		2,48	5,94	**	2,54	4,35	*	2,50
Mean parent education school	22,54	***	1,32	17,94	***	1,35	17,91	***	1,33
Mean nb of books school	30,58	***	1,70	33,98	***	1,74	31,34	***	1,72
Vocational school	-17,28	***	1,44	-19,00	***	1,48	-19,65	***	1,46
Country dummies	yes			yes			yes		

,,*** stand for significance at the 10%, 5% and 1% level of confidence respectively.*
Number of observations: 36 290

Table 5 presents the results of the estimation of specification 4, with crossed effects PERCENTSELECT times SCHOOLSELECTS. Pupils attending a selective school respectively obtain 9.52 and 8.67 higher test score points in Maths and in Science. In this specification, the coefficient of PERCENTSELECT is reduced by nearly half (to between 10.09 points in reading, and 9.31 points in science) whereas the crossed effect is significantly positive for all three disciplines. This implies that pupils inside selective schools seem to benefit most from higher regional school selectivity but that there is still a positive correlation between test scores and PERCENTSELECT for

pupils outside selective schools. A possible explanation is the higher incentive to pupil effort at the end of primary school when more secondary schools are selective. In the usual absence of objective information on school quality in Europe, school selectivity is a strong signal of peer quality. As the percentage of selective schools increases so does the chance of admittance and the incentive to effort.

Moreover, we observe that the correlation between peer quality and test scores is stronger than between attending a selective school or PERCENTCHOICE and test scores, suggesting that mixing pupils (avoiding sorting of pupils) may be an important policy objective when implementing school choice.

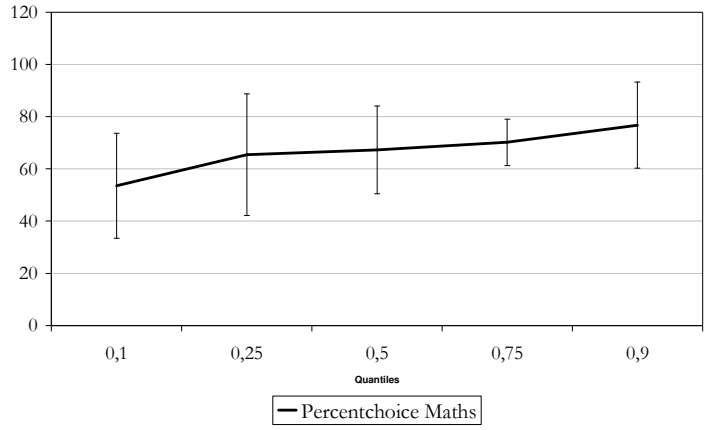
Table 5: Estimates specification 3 (crossed effects), Dependant variable: test scores in Maths, Reading and Science.

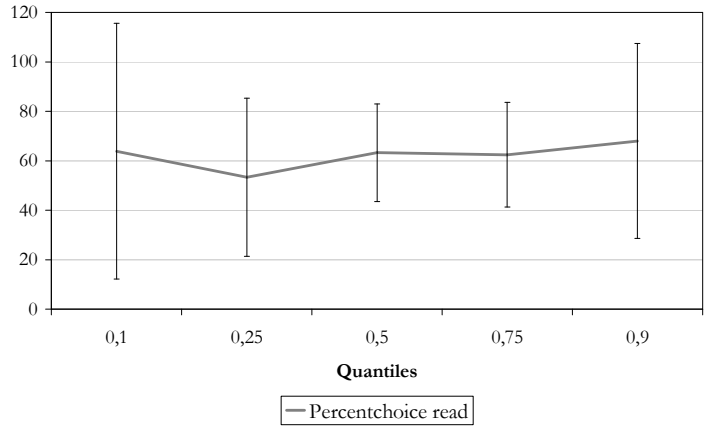
	Maths			**Read**			**Science**		
Effect	Coeff.		StdErr	Coeff.		StdErr	Coeff.		StdErr
Intercept	64,10	*	36,45	173,68	***	34,82	24,02		33,57
Percentchoice	62,48	***	23,04	66,31	***	20,78	61,15	***	19,73
Percentselect	43,74	**	17,80	43,91	***	16,32	40,46	**	15,56
Schoolselects*percentselect	45,99	***	9,43	36,80	***	9,66	37,19	***	9,46
Schoolselects	9,52	**	3,77	6,79		3,85	8,69	**	3,77
Socio eco status region	-2,45	***	0,71	-2,48	***	0,64	-2,38	***	0,61
Class size region	-0,60		0,51	-0,21		0,46	-0,25		0,44
Unemployment rate region	-0,89		0,68	-0,73		0,61	-0,38		0,58
Boy	24,36	***	0,78	-28,25	***	0,81	10,45	***	0,79
Age	0,08		1,35	-4,39	***	1,40	4,79	***	1,37
Number of books at home	9,31	***	0,34	6,38	***	0,35	8,73	***	0,35
Non-nuclear family	-6,84	***	0,83	-6,75	***	0,86	-1,00		0,84
Home educ Resources	7,02	***	0,37	7,56	***	0,38	6,14	***	0,38
Parents' education	1,06	***	0,25	1,06	***	0,26	1,65	***	0,26
City size	-1,44		0,71	0,60		0,73	-2,19	**	0,71
Grade	27,15	***	0,76	26,99	***	0,78	24,91	***	0,77
School educ. Material	2,62	***	0,66	2,24	***	0,68	2,53	***	0,67
Centralbudget	6,86	***	1,47	4,18	*	1,51	4,78	***	1,47
Centralcontent	-1,51		1,40	-1,73		1,44	0,58		1,41
Centralhiring	2,75		2,32	4,57		2,38	2,19		2,34
Centralwage	4,52	*	2,47	5,69	**	2,54	3,41		2,49
Mean parent education school	20,16	***	1,33	16,11	***	1,36	16,18	***	1,33
Mean nb of books school	29,33	***	1,70	33,01	***	1,74	29,37	***	1,71
Vocational school	-20,02	***	1,45	-21,11	***	1,49	-21,56	***	1,46
Country dummies	yes			yes			yes		

,,*** stand for significance at the 10%, 5% and 1% level of confidence respectively.*
Number of observations: 36 290

The quantile regression estimates for the different quantiles of student test scores and their 99% confidence intervals are presented in Figures 3 and 4. They represent the coefficients of PERCENTCHOICE and PERCENTSELECT for the five quantiles of pupil performance defined in section 4.

Figure 3: Coefficients of PERCENTCHOICE, by quantile - Estimates from quantile regression specification 2, 99% confidence interval. - Dependant variable: Test scores in maths, reading and science.





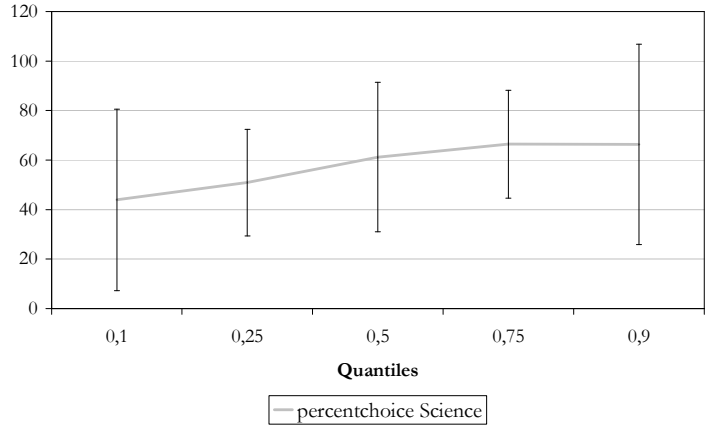
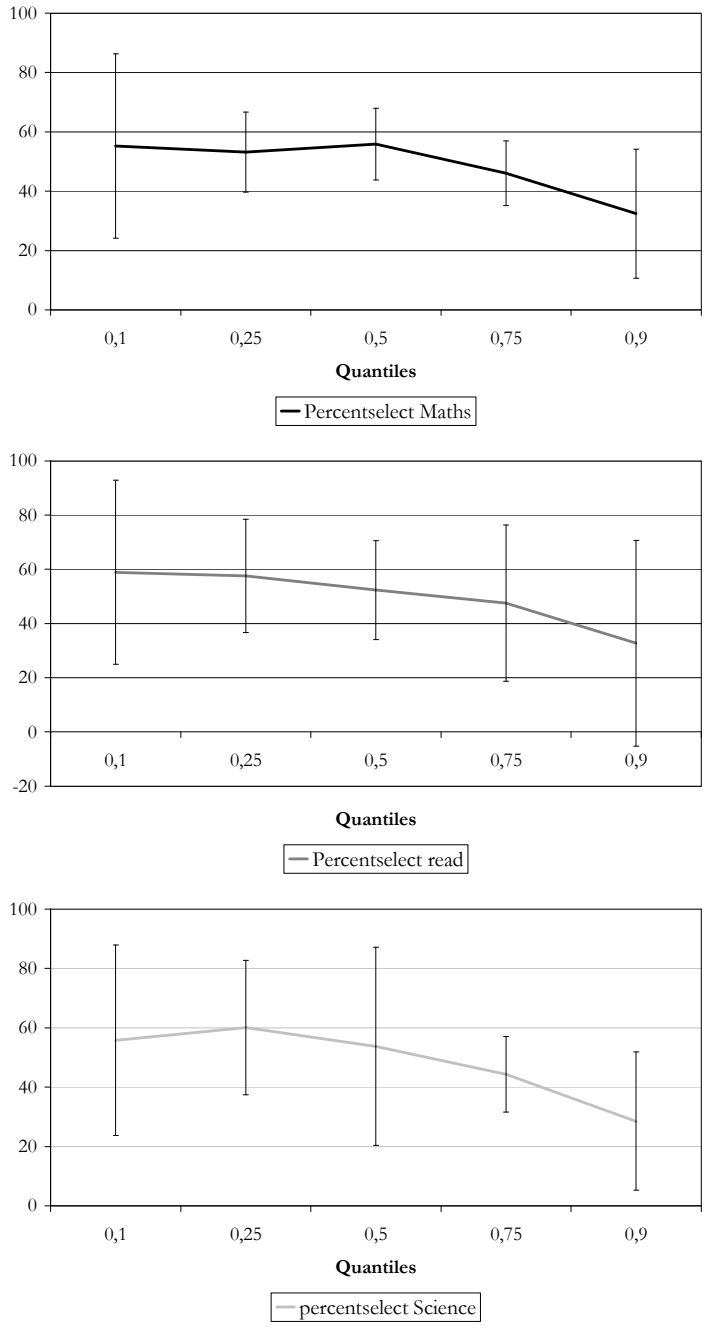


Figure 4 : Coefficients of PERCENTSELECT, by quantile - Estimates from quantile regression specification 2, 99% confidence interval. - Dependant variable: Test scores in maths, reading and science



It appears that there is an increasing trend in the coefficient of PERCENTCHOICE in Maths and in Science. However the difference between coefficients at the different quantiles is not significantly different from zero. The coefficients of PERCENTSELECT show a non significant decreasing trend as we move up the quantiles of student performance in all disciplines. We interpret these results as suggesting that there are no significant differences in the way the regional intensity of school choice and of school selectivity affect low versus better performing pupils.

6. Conclusion

In this paper, we estimate how the regional intensity of school choice and the regional percentage of selective schools relate to student test scores in math, reading and science at age 15. In order to be able to control for unobserved country effects with country dummies, we include in our sample only countries with centralised educational systems. We estimate a classical education production function taking into account the hierarchical nature of the data.

The regional intensity of school choice is measured as the regional percentage of pupils that claim to be in their school because it is know to be a good school. Including only the regional intensity of school choice yields a significant positive correlation with student test scores in all three disciplines.

In the absence of reliable information on school quality, school choice may lead to pupil sorting by ability and observed characteristics. In a second specification, we aim to disentangle the effect of pupil sorting by ability from the 'residual' effect of school choice. Therefore we include two measures of school-peers' quality and the regional percentage of selective schools in the estimation. Peer quality is measured as the mean level of parents' education in the school, and the mean number of books at the home of peer pupils. As a result, the coefficient of the regional intensity of school choice is reduced by about 25% in all three disciplines (to between 9.98 and 9.34 test scores points) but remains significantly positive. This 'residual' coefficient of the regional intensity of school choice measures its correlation with test scores net of pupil sorting and peer effects. Theoretical arguments suggest this includes the correlation between increased school effort induced by school choice and test scores.

Regional school selectivity is measured as the regional percentage of school directors that claim student academic records are a high priority or a prerequisite for admission. We find that regional school selectivity is significantly and positively correlated with test scores. This is an indication that the positive effects of school selectivity (related to e.g. incentive to effort at the end of primary school or benefits of adapted teaching methods) seem to dominate the negative ones (related to e.g. lower teacher expectations in non selective schools).

In addition, we observe that the correlation between peer quality and test scores is stronger than between attending a selective school or PERCENTCHOICE and test scores, suggesting that avoiding sorting of pupils may be an important policy objective when implementing school choice.

Pupils inside selective schools seem to benefit most from higher regional school selectivity but there is also a positive correlation between test scores and regional school selectivity for pupils outside selective schools. This finding is inline with the hypothesis that school selectivity may provide incentives to effort similar to those of an external examination.

Finally, in order to investigate whether school choice and pupil sorting affect low versus high performing pupils differently in our model, we apply the quantile regression procedure to specification 2. We do not find significant differences in the way the regional intensity of school choice and of school selectivity affect low versus better performing pupils.

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