School choice, equity and efficiency: International evidence from PISA-2012

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ABSTRACT

School choice is one of the most researched topics in the educational sciences in the last decades. Its importance in reorganizing educational systems in many countries is unquestionable. Current literature underline that its impact should be positive under certain policy framework: this is because the main worries on school choice are about segregation problems or results on equity.
This paper has two research objectives. First, our interest will be to assess the extent to which choice and choice-equity mechanisms influence school efficiency, and secondly, understand in the case of choice-equity mechanisms, if the effects over efficiency are somehow related to social composition or the results of competition
The study is done at international level, using OECD-PISA2012 data from 39 countries. The methodology is based on building an efficiency function based on non-parametric techniques firstly, and on econometric modelling of both choice variables solely and composite choice-equity measures over school efficiency by means of truncated regression. Our results achieved suggest that effects of choice and choice-equity mechanisms vary. As for choice measures solely no concluding evidence was found. In contrast, when considering combined choice-equity measures, positive effects accrue when parents/students have the right to enrol in any school of their choice. Nevertheless, we have to say that these results are only applicable specifically to the percentage of students in schools having an average SES level (student-intake) of student composition in their schools.

Key words: School choice, equity, education, school efficiency, DEA, PISA-2012. JEL: I24, I28

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INTRODUCTION

Traditionally, well-off families have "exercised" school choice throughout residential mobility or through enrolling their pupils in private schools, however, less affluent families have played in an unequal field. Despite the (more political) debate among advocates and opponents to school choice, literature (Chubb and Moe, 1990; Hoxby, 1999, 2000 and 2003, Nechyba, 2003) suggest that if students usually assigned to some "public" school in their neighborhood have the general right to enroll the school of their choice, they can benefit from higher quality education (efficient). From a theoretical perspective, choice programs aim to create a competitive market that forces schools to compete for consumers, by moving over the production frontier when trying to match with students/parents demand for educational services (Betts and Loveless, 2005). Nevertheless, empirical research (Ladd and Walsh, 2002; Ladd, 2003; Soderstrom and Uusitalo, 2005; Field et al, 2007; Ladd, Fiske and Riujs, 2009; Ladd and Fisk, 2011; Musset 2012,) have shown that (some) externalities of implementing (parental) school choice solely, can exacerbate inequities, as it increases the sorting of students (or segregation) between schools by pupil characteristics (e.g. socioeconomic status, ethnic origin or ability), leading to differences in student outcomes (Hastings, Kane and Staiger, 2005, 2006) and not so clear impact over school productivity[2] (Ladd, 2003, Belfield and Levin, 2001). Therefore a tradeoff between school choice and equity exists with not so clear impact over students and schools (Waslander et al, 2010; Ladd, Fisk and Riujs, 2011; Muset, 2012).

These results relies in the facts that parental preferences for choice decision, on the one side, are somehow irrational (Ladd, 2003) in the sense that there are multiple factors, besides school quality, that parents consider important when deciding which school attend/enroll their children (e.g. school social composition or proximity), and secondly, more affluent and educated parents effectively exercise choice in contrast to less affluent ones despite potentially benefiting from choice schemes (Musset, 2012). These two considerations lead to widen segregation (between schools), namely by the "flight of students to higher SES" (Ladd, 2003), this is, students enrolling in the schools of their choice benefit from an ample variety of schooling options (e.g. normally schools of higher socio-economic level, capable to command more resources and to attract and retain higher quality teachers, Ladd and Walsh, 2002). In contrast, students remaining in their neighborhood (public assigned) school, despite the fact these schools "can benefit from competition effects" (schools will improve their performance to attract students, Hoxby, 2006, or preventing more "flights", Ladd, 2003), the change in their student body composition (departure of high-performing students) might hurt the overall

[2] Hoxby (2003) defines productivity as the ratio of student achievement and expenditure per pupil. In her research (using data from the Milwaukee, Michigan and Arizona programs) she presents empirical evidence on how choice affects school productivity and student achievement, given the "competition" created by voucher programmes and charter schools between public and private schools. Results achieved suggest that relevant competition effects exist over public schools, especially in those that initially had below-average achievement. Hoxby emphasise that policies targeting productivity increase should be led by raising student outcomes.

(student and) school performance (Ladd, 2003), more if qualified teachers leave or even reduce their resources (budgetary) due to reallocation (Musset, 2012).

Recent empirical research suggest that choice schemes considering equity issues: namely by integrating students (Angrist and Lang, 2004) of different socioeconomic level (ethnicity or abilities) and supporting those more disadvantage (Elacqua, 2009), can lead to improve student outcomes and provide the right incentives for schools to enroll more disadvantage students (reducing segregation), but also, lead to better distributing students across schools in terms of social composition (integration). Therefore, measures aimed at "easing parental school choice" targeting more student cohesion in terms of average social composition should benefit students in general, however, in this context, of especial interest is to understand to what extent can choice-equity schemes influence school efficiency, and if so, likewise understand if these effects are related to social composition effects or namely as a result of competition (e.g. from choice instrument).

With this in mind, our research relies on the idea that choice mechanisms leveling the playing field and providing the same opportunities for every student has at its heart the importance of well managing school composition (e.g. admission/enrolment policies), as it benefits individual students and provides incentives to schools to enroll more disadvantage. Hence, our research objective is twofold. First, our interest will be to assess the extent to which choice and choice-equity mechanisms influence school efficiency[3], and secondly, understand in the case of choice-equity mechanisms, if the effects over efficiency are somehow related to social composition or the results of competition.

Therefore, our research hypothesis would be:

We have observed that the literature suggest on the one hand, that choice mechanisms can improve school productivity (Hoxby, 2003) given the increase of competition (students opting out for "better schools" by exercising school choice), thus providing the "right incentives" to (local neighborhood) schools to improve their productivity to attract more students (Hoxby, 2006). However, we must emphasise that research (Waslander et al, 2010, Musset, 2012, Belfield and Levin, 2005) suggest that choice measures taken in isolation, appear to be rather inconsistent in terms of student achievement and school efficiency.

Our interest aims at assessing the effects of competition derived from choice mechanisms (freedom of choice, vouchers vouchers/funding following students and tuition tax credits) over school efficiency, therefore:

[3] To clarify the concept of efficiency used in our research, we follow Levin (2009, pp.30), suggesting that the productive efficiency of an educational approach which considers both costs and educational outcomes of any particular form of school organisation have been an issue of disagreements, as costs and outcomes are not transparent. In fact Levin (2009, pp.30) emphasis: *"Comparison of costs of schools under different choice approaches are virtually non-existent or when attempted are casual rather than systematic. That is, there exist no rigorous cost studies based upon standard cost methods (Levin and McEwan, 2001) that have compared traditional public schools with schools of choice (e.g. private or charter schools) and that take account of comparable student and services (Levin (1988)".* Therefore, when talking about school efficiency, we will refer to technical efficiency.

Hypothesis 1: Choice mechanisms alone hardly create "competition effects" leading to increase school efficiency.

On the other hand, considering the fact that integration can lead to positive effects for disadvantage students without hindering top-performer (Ladd and Walsh, 2002; Angrist and Lang, 2004; Hanushek, 2003[4]), school efficiency should increase as students better distribute (by exercising choice) across schools in terms of social composition (integration). This argumentation can also be underpinned in the sense that schools serving more "advantage students" are able to command more resources and attract and retain higher quality teachers (Ladd, Fiske and Ruijs, 2011; Perry, 2007[5]).

In this case, our interest will be to uncover the effects of school composition-choice mechanisms over school efficiency, by clearly identifying if these effects are related to social composition or the results of competition, therefore:

Hypothesis 2: Choice-equity mechanisms improve school efficiency, which are driven by controlling the composition of student body in schools.

To do so, using country aggregated variables from PISA-2012 database, our research will encompass a two stage analysis: First, we build a simple production function implementing a Data Envelope Analysis (DEA) technique to compute productive (in)efficiency scores of schools by considering a bundle (or well grouped) of “controllable” inputs (students socioeconomic and cultural status, percentage of full time teachers certified and the average weekly time spent for learning in reading, math and science) and as outputs, we have considered student achievement (the average student test scores in the domains of reading, math and science of PISA2012), and second, we use a truncated regression[6] to estimate the effects of discretionary or non-controllable variables[7] (choice and financial mechanisms as well as balanced choice-equity schemes) over the country-school efficiency scores.

Therefore, this paper is structured as follows. Section 1. present the conceptual framework by high lightening the key elements of school choice, equity and efficiency. Linking the three economic concepts; efficiency, school-choice (& competition) and equity, will provide the basis to set our empirical model. In section 2 we describe both the data and the variables used. Section 3 presents the methodology used, a two-step analysis: First, to compute the efficiency scores

[4] Hanushek(2003), argues that a strong relation exist between student achievement and SES status of students' peers, consequently, choice arrangements increasing integration are likely to increase student achievement as well.

[5] Perry's (2007) reading of Dronkers and Roberts (2003) study, suggest that despite differences (in reading test scores) between public and private-dependent schools can be attributed to differences in the composition of student body, these latter schools also benefit of a steady stream of funding and institutional autonomy.

[6] To prevent possible bias estimations we use bootstrap techniques (Simar and Wilson, 2007, 2011).

[7] Choice and equity issues are normally "controlled" out of schools by education authorities by means of financial support, regulation and/or technical assistance (Levin, 2009). Examples range from conferring families the right to choose the school of their choice (empower), regulation of the admission policies by schools (especially when oversubscribe), providing school autonomy (to enhance diversity of education provision), effective and transparent information and financial support to parents to exercise choice as well as technical assisting and funding to schools (especially those underperforming which need extra resources or technical assistance to better implement organization of instruction when given autonomy).

we use a non-parametric efficiency Data Envelope Analysis (DEA) technique and secondly, we use a truncated regression to assess the choice and choice-equity variables over the efficiency scores. Both techniques underpin its adequacy to appraise the relation between our key concepts and main concern of our research. Section 4 presents the general results and discussion, including a brief robustness analysis. Last (Section 5), addresses the final remarks and conclusions, giving response to our research objectives/hypothesis, and also entails some discussion of its implications (in terms of education and economic policy).

CHOICE, EQUITY AND SCHOOL EFFICIENCY: A CONCEPTUAL FRAMEWORK

Enhancing educational choice (to families) would introduce more competition between schools and thus improve their performance, in terms of (productive) efficiency (Levin, 2009). In this equation, public benefits of education would be captured by requiring schools that receive public financing to meet certain standards for approval. A large variety of schools[8] would compete for students, and parents would choose from among government-approved schools in the educational marketplace and could supplement education vouchers from their own finance (Friedman and Scott, 2005 as cited in Levin, 2009).

Parental choice and school efficiency: The role of school composition.

The core idea of school choice is that students should be free to choose between schools that compete for them within the same playing level (Musset, 2012). Theoretically, choice programs aim to create a competitive market that forces schools to compete for consumers (Betts, 2005), by moving over the production frontier when trying to match with students/parents demand for educational services (Betts and Loveless, 2005). This means that choice and competition can lead to improve student outcomes (as they maximize their decision of choosing among different schools) and provide the right incentives to schools to compete for students (maximizing their student-intake among the existing students - characteristics) by providing better education oriented to satisfy parental/student demands.

However, the extent to which school choice schemes lead to improve the quality of education is a "hearty debate" (Musset, 2012). How choice schemes improve student achievement relies on parents capacity and willingness to send their children to better schools, as for school performance gains (as a consequence of competition), it depends on how effectively schools use their resources to meet parental/student demands and needs. In any case, most empirical work proves that school choice can bias equitable schooling (Ladd, 2003; Ladd and Walsh, 2000, Ladd and Fiske, 2009) increasing inequality and segregation, questioning its effects (choice and competition) over student performance and school efficiency.

In this dynamics, three elements become relevant which are mutually related: Choice preferences, school efficiency and school composition.

[8] For profit, not-for profit, including many different education approaches (e.g. religious, etc.)

Parental choice. Parental preferences for choice decision are somehow irrational (Ladd, 2003). To decide which school to attend/enrol their children, parents consider multiple variables besides school quality, such as school social composition or proximity. Furthermore, more affluent and educated parents effectively exercise choice in contrast to less affluent ones, despite potentially benefiting from choice schemes (Musset, 2012). This means that parents when choosing the school of their choice considers both educational and social reasons (Denesse, Sleegers, Smit, 2001, Ladd, 2003). In fact, empirical literature concludes that parents prefer schools with populations ethnically and socioeconomically similar or higher than that of their original or assigned school (Ladd, 2003; Fiske and Ladd, 2000 for New Zealand; McEwan and Carnoy, 2000, for Chile; Whillms and Echols, 1993 for Scotland; Cullen, Jacob and and Levitt, 2000 for Chicago; Crozier et al, 2008 for the UK and Reveaud and Van Zanten, 2007 for France).

These findings suggest that many parents are aware that the social composition of a school (beside traditional educational programmes) influences academic achievement (Perry, 2007). In fact, this *"customer mix"* (Ladd, 2003, pp.69-70) have three important implications over educational systems in general. First, education systems having full parental choice hierarchy of schools emerge (in the sense of Epple and Romano, 1998[9]). Second, when school student body becomes a relevant characteristic of school quality[10], no strategy can make a school overrepresented by low achievers (including SES), look effective. Third, successful schools will be reluctant to changing their "*mix of students*" that makes them attractive to parents (Fiske and Ladd, 2000).

School efficiency. An increase in parental choice will provide competitive pressure on public schools to improve their performance (productivity). The underlying rational is that as school competition increases (namely by students opting out for "better schools" exercising choice), the "right incentives" will be provided to (local neighborhood) schools to improve their productivity and that way attract more students (Hoxby, 2006). This dynamics underlies in three essential elements (Hoxby, 2006): Supply flexibility, money that follow students and independent management of schools. However, we must emphasise that research (Waslander et al. 2010; Musset, 2012) suggest that studies analysing choice measures taken in isolation, appear to be rather inconsistent and those which showed positive effects where rather small (besides from those suffering methodological difficulties). Of special consideration (given our research) are studies considering PISA data (OECD, 2010a; OECD, 2011), suggesting that no correlation/relationship exist between the degree of competition (proportion of schools) and student performance (controlling and not by student SES). Similar results can be found in Agasisti (2009) for the Italian case[11].

[9] Epple and Romano model competition effects between private and public schools. Results achieved suggest that in an open public enrollment system where public and private schools are equally effective on delivering education, those benefiting from the introduction of a voucher programs will be "low income high achievers students", as the introduction of vouchers will lead to an entry of new private schools and movements of students from the public to the private schools. Those students staying in the public schools (low income and low ability), will be those experiencing losses.

[10] Following Ladd, Fisk and Ruijs (2011), schools serving advantage students are generally considered of higher quality than schools serving disadvantage students, as they are able to command more resources as well as attract and retain higher quality teachers.

[11] To this extent, our research considers school choice mechanisms (policy instruments), at system level, rather than direct "competition" effects at school level.

However, Ladd's (2003) review of Hoxby's (2003) conclusions suggest an alternative explanation: schools that experience higher gains in test scores (including those new enrolled students with below-average test scores who opt out of their traditional public schools), are not due to effects of competition and the raise of productivity, but simply to a change in their student body composition[12], further, as for the public (neighborhood) school, the change in the student body composition (given the departure of high-performing students) might hurt the overall school performance, more if qualified teachers leave or even reduce their resources due to reallocation (Musset, 2012). From Ladd's perspective, the above suggest that a change in the social composition of schools can affect productivity gains (and student outcomes).

Social composition of schools. From the above, we can derive three clear considerations (See figure 1). First, that school choice can positively but more often negatively affect school composition (segregation), secondly, that social composition of schools can positively or negatively affect families choice of school (deciding which school to attend) (Perry, 2007), From these two considerations, we can derive a third one, school choice (competition) and school composition have the potential to impact (positively or negatively) school efficiency[13] (and student outcomes)[14]. This latter consideration suggest an important trade off in terms of choice-equity as overrepresentation of students (high or low) can influence school efficiency in opposite directions. Schools over represented by lower SES students can lead to an increase of educational challenges for both the school and student who remain there (Perry, 2007), in this situation, schools (theoretically) can but not necessarily, improve their efficiency.

Recent literature has proven that choice schemes considering equity issues, namely, integration of students (Angrist and Lang, 2004) from different socioeconomic levels and supporting those more disadvantage (Elacqua, 2009) can lead to improve student outcomes, but also, provide the right incentives for schools to enroll more disadvantage students (reducing segregation), as well as better distributing students across schools in terms of social composition (integration)[15]. The underlying rational is to introduce/enforce (controlled admission) mechanisms to ensure more diversely distributed students across schools (flexible enrollment plans) in terms of school social composition, and/or implement financial support, where funding fol-

[12] In this statement, Ladd (2003, pp.74) emphasize over Hoxby's research, referring that "competing schools" (private and charter schools in Milwaukee) could experienced higher gains in test-scores gain even if they had not experience productivity gains.

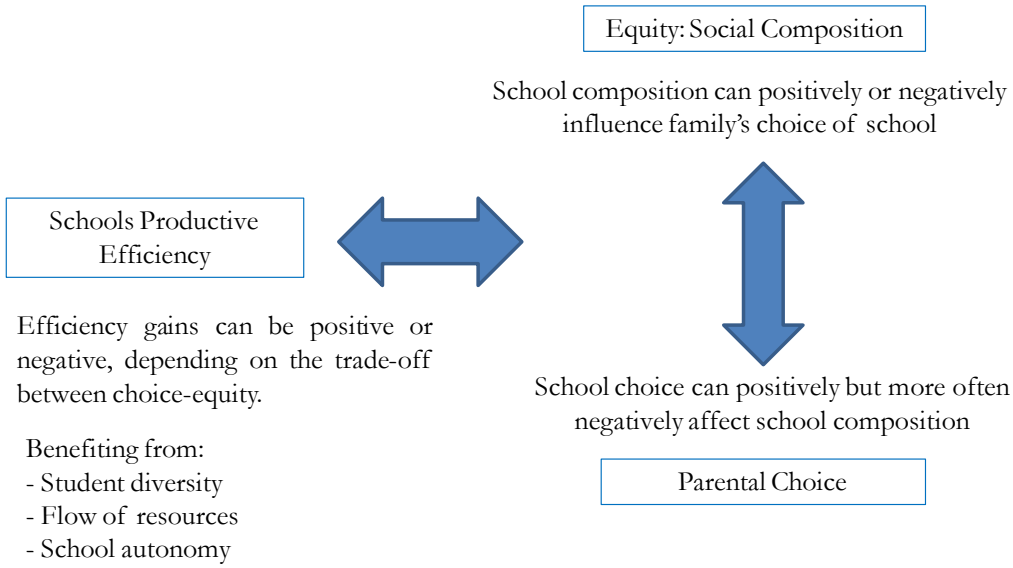
[13] Epple and Romano have modeled competition between public and private schools (see Epple & Romano, 1995; Epple et al, 1997; Epple & Romano, 1998) by relating different "relevant variables" in the schooling process. They have included preferences, production process factors, costs and institutional structures. They even suggest possible extensions to the model - such as peer and teacher characteristics. From their research, Epple and Romano conclude that, given competition between public and private schools, (where high-ability and low-income move to private schools, and low-ability and low-income remain un public schools) gains of technical efficiency from vouchers in public open enrollment education systems is an open question, but suggest from their own findings that vouchers do have an important allocative effects which implies relevant distributional effects.

[14] One more consideration can be done from our analysis, which is the strong relation that composition of student body has over student outcomes (Hanushek, 2003; Ladd, 2003).

[15] An interesting result from Epple and Romano (1998) research finding important allocative effects of vouchers are the implications for the design of vouchers, namely if they should be oriented to improve technical efficiency without increasing ability segregation, less able students will need more financial assistance or equivalent control must be enacted.

low students (disadvantage or low performers) on a per-student basis to the school they attend and this amount depends on the educational needs of each children (Musset, 2012).

Figure 1: Choice-equity trade-off and School Efficiency



Source: Own elaboration based on Hoxby (2003 and 2006), Ladd (2003), and Perry(2009)

As an important trade-off exist between choice and equity, controlling choice-equity schemes (limiting segregation issues and financially supporting parental choice) have the potential to improve school efficiency, by clearly benefiting from student diversity and higher resources. Furthermore, schools with more diverse student body can increase the opportunity to students to develop novel abilities, such as tolerance or empathy. In fact, novel research in this line suggest that interactions between culturally diverse students (in and out the classroom), is correlated with higher levels of complex thinking (Antonio et al, 2004), cultural awareness and political participation (Johnson & Lollar, 2002) and active thinking, tolerance and empathy (Gurin, Dey, Hurtado and Gurin, 2002), as cited by Perry (2007).

DATA AND VARIABLE DESCRIPTION

The data

The data used in this research come from the Program for International Student Assessment (PISA) 2012[16], and refers to country-aggregated level data concerning 39[17] countries and economies. Of these 39 countries, 34 countries are official members of the OECD and the remaining countries and economies (5), refer to partners or contributors with this institution (Argentina, Brazil, Hong Kong SAR, Indonesia and the Russian Federation).

[16] PISA databases have been designed to allow cross-country comparisons (Hanushek et al, 1996; Santin, 2006, Salinas and Santin, 2011)

[17] The fact we have selected 39 countries is mainly due to "data availability".

The selection criteria for choosing these countries and economies from the PISA 2012 results has been the availability of the data under research, specially, data related to choice instruments in the different countries and economies analyzed. Moreover, we have to mention that PISA 2012 does not include data from choice instruments at system level (existence and applicable in each of our study countries and economies). This fact, has lead us to use choice instruments information from PISA 2009 database, in the understanding that "policy measures change slowly in countries" therefore, can be applicable to our analysis.

PISA is an international assessment survey that measures students' abilities in the domains of reading, mathematics and science. According to the OECD (2012a), PISA focuses on young people's ability to use their knowledge and skills to face the challenges of real life and not to master a specific curriculum. Moreover, PISA takes place every three years, focusing on 15 year old students, from OECD and partner countries. Five waves of PISA have taken place, namely 2000, 2003, 2006, 2009 and 2012. The PISA 2012 survey covers 65 countries around the world. In addition, each wave has focused on a specific domain. In 2000 the focus was on reading, in 2003 its' focus was in mathematics and lastly, in 2006 it focused in science. The PISA-2009 and 2012 editions focused again in reading and mathematics literacy respectively.

Variable Description

To choose (and assess the effects of) the variables considered in our research, we have followed our conceptual framework discussed in section 2. This is, for measuring technical efficiency we considered a set of inputs/outputs of education production normally controlled by schools. As for choice and equity schemes, variables considered are determined independently from schools, this is, variables are determined normally by education authorities (choice) and parents (school composition, as a result of parental preferences). Our interest will be to clearly answer the research questions addressed in section 1 by means of investigating the existing causal (statistical) relationship between choice and choice-equity measures with technical efficiency.

First stage variable description:

More specifically, aiming at estimating school technical efficiency scores (at country aggregated level), inputs and outputs have been choose in accordance to both, (a) what choice-equity education literature (Ladd and Walsh, 2002; Ladd, 2003; Ladd and Fiske, 2009; Ladd, Fiske and Riujs, 2009) had identified as having "certain influence" over schooling when choice schemes have been set out[18], and (b) in accordance to what efficiency literature (Farrel, 1957; Groskhop

[18] To this regard, we have to recognise that production function literature (Bowles, 1970; Levin et al, 1976; Hanushek, 1986 and 1992, among others) envisage an ample set of determinants that should be considered when analysing student outcomes, which includes among others, student (emphasising their social and cultural background) and school specific characteristics. Furthermore, certain modelling recommendations (Boardman and Murnane, 1979; Todd and Wolpin, 2003) for estimating educational achievement determinants have also been set out. These recommendations caution of possible unobservable effects or aggregated level data. To this end, our research exercise pursues to estimate technical efficiency scores of a group of specific factors over traditional student outcomes, which can (or cannot) be affected by choice or choice-equity schemes. However, we

et alter, 1978, Coelli, 2001, Alvarez Pinilla et al, 2001, Simar and Wilson, 2000 and 2007 among others) considered "controllable factors" by any decision making unit (DMU) during the "educational" production process.

However, we must emphasise that the concept of inefficiency suggest a waste of existing resources when carrying out a productive activity (Salinas and Santin, 2011). In fact according these authors, education provision embodies both student and schools resources, thus students' inputs such as individual and familiar characteristics or school variables (e.g. the pedagogical methods or management practices) can influence school efficiency. In this context, despite adequate values of some inputs, output results can be low when compared to those of similar students in the same situation. Perhaps due to inefficient behaviours of education actors which do not properly fulfil its role when transforming school resources (inputs) into effective learning (leading to optimal outputs). This situation leads to a lower amount of outputs (given a level of inputs) or a greater amount of resources (to achieve a specific level of output) compared to what it could be obtained.

Therefore, the following input-output data was used:

Output variable. The dependant variable will be the average of the test scores achieved by students in the domain of math, science and reading (table 1). The argument for choosing these set of variables is namely that student achievement (measures as test scores) have been considered one of the most important outcomes of schooling as well as for economic growth (Hanushek and Woessmann, 2007). With respect to test scores, we must say that PISA uses matrix sampling of items to ensure an acceptable rate of coverage and participation of students in each domain (reading, mathematics and science). It divides a long test booklet in several shorter booklets (implementing the balanced-incomplete-blocks design, BIB). Each student is assigned randomly to a single (short) booklet. Therefore, as different students completes one (long) booklet, the score cannot be computed in a traditional way, but rather, using plausible values (see Adams and Wu, 2002).

For each literacy-domain (reading, mathematics and science), PISA2012 data reports for each student, five plausible values. The general scale used[19], is transformed to reach an average of 500 (points) with a standard deviation of 100 (points) using a linear transformation. When a student's score is close to a point of the scale, it's more likely that students successfully respond to the items that are at that point or below it (score) and likewise, students are less likely to respond to items that are above that score. It's worth mentioning that for our empirical analysis, in order to estimate the unbiased "population" estimates of our interest, we have followed the PISA Data Analysis Manual (OECD, 2009, pp. 129-130) to compute country average test scores.

are plenty aware of the importance of other multiplicity of factors that can influence both student outcomes and school efficiency (see Epple and Romano, 1995, 1998; Epple Newlon and Romano, 1997)

[19] This is estimated on standardized scores, which are based on mean zero and standard deviation 1. OECD-PISA (2012a)

Input variables. Independent variables are presented herein below (table 1) following our conceptual framework in section 2. More specifically, research on the effects of choice-equity measures suggest that when equity is considered (by weighted student-funding formulas or even integration of students) and effective distribution of different resources to schools exist (Epple and Romano, 1998, Ladd and Fiske, 2009). Moreover, these kind of choice-equity mechanisms normally do not require that schools use directly these "extra resources" over specific students, but opens to school the best or most suitable way to use them. Research evidence has shown that some schools have increased the number of teachers per pupil or even their support staff (Ladd and Fiske, 2009). Moreover, we have argued that students' individual and familiar background (Salinas and Santin, 2011; Kirjavainen and Loikkainenn, 1998) also influence school performance (especially when measured as student outcomes). Therefore, socioeconomic and cultural characteristics of students become determinant in our simple production function specification.

Hence, considering the importance of socioeconomic and cultural characteristics of students (Coleman et al, 1966; Gamoran and Long, 2006; Salinas y Santin, 2011), the important allocative effects of vouchers (Epple and Romano, 1998) and that school processes[20] become relevant for improving education performance, as schools can and do have a fair amount of control over how they are organized and managed, the teaching practices they use, and the climate they create for student learning (Bryk & Thum,1989, Gamoran, 1996; Rumberger and Palardy, 2004), our independent variables considered will refer to the ESCS of students and the organisation of instruction.

Therefore, independent variables considered are (a) student average country socio economic and cultural status,[21] (avgESCS country average) (b) ratio of full time teachers certified to full time teachers (avgFTC country average), and (c) the total weekly instruction time (learning time) for reading, math and science, which is the overall sum of the average number of minutes during one week where students attend reading, math and science class (totINStime country average).

[20] In accordance to this line of research, learning is a result of schooling, and school processes transform school resources into learning.

[21] The Index of Socioeconomic Status and Cultural Level (SES) computed by OECD (OECD,2011), is an indicator that encompasses three components associated with the student's familiar and home environment, namely, (1) the level of parental occupation (job position), (2) the level of educational attainment of parents expressed in years of schooling and (3) the rate of student possessions at home. This last component in turn encompass family welfare, cultural possessions and educational resources available in their homes, including the number of books. We present average country SES variables associated each of the 39 countries analyzed. A lower SES value, is associated with a lower SES level and vice-versa, the higher the value, the greater the SES level. SES individual scores are computed in two steps. First, they estimate the international indicators, using principal components analysis for OECD countries. Once international values are computed, weighted likelihood estimation techniques (Warm, 1989) are employed to compute individual student scores (OECD, 2012b). A detailed description can be found in OECD, 2012a, PISA 2009 Technical Report, PISA, OECD Publishing, Chapter 16 "Scaling Routines and construct validations for context", p. 279-316.

Table 1: First stage Analysis: Outputs and Inputs Variables

COUNTRY	AVGread	AVGmath	AVGscien	AVGindex	avgESCS	avgFTC*	totINStime
Argentina	396	388	406	397	-0,72	0,860	747,5
Australia	512	504	521	512	0,25	0,980	696,8
Austria	490	506	506	500	0,08	0,894	500,5
Belgium	509	515	505	510	0,15	0,882	626,9
Brazil	410	391	405	402	-1,17	1,000	584,3
Canada	523	518	525	522	0,41	0,947	936,1
Chile	441	423	445	436	-0,58	0,208	1067,7
Czech Rep	493	499	508	500	-0,07	0,927	577,8
Denmark	496	500	498	498	0,43	0,960	715,7
Estonia	516	521	541	526	0,11	0,972	617,1
Finland	524	519	545	529	0,36	0,894	516,2
France	505	495	499	500	-0,04	0,818	595,6
Germany	508	514	524	515	0,19	0,953	642,3
Greece	477	453	467	466	-0,06	0,767	608,7
Hong Kong	545	561	555	554	-0,79	0,961	782,8
Hungary	488	477	494	487	-0,25	1,000	507,2
Iceland	483	493	478	484	0,78	0,962	623,2
Indonesia	396	375	382	384	-1,80	0,653	590,2
Ireland	523	501	522	516	0,13	0,998	514,8
Israel	486	466	470	474	0,17	0,772	643,1
Italy	490	485	494	490	-0,05	0,856	644,8
Japan	538	536	547	540	-0,07	1,000	604,9
Korea	536	554	538	542	0,01	0,999	616,5
Luxembourg	488	490	491	490	0,07	0,733	549,7
Mexico	424	413	415	417	-1,11	0,315	737,1
Netherlands	511	523	522	519	0,23	0,855	504,1
New Zealand	512	500	516	509	0,04	0,960	731,3
Norway	504	489	495	496	0,46	0,897	561,2
Poland	518	518	526	521	-0,21	0,991	587,1
Portugal	488	487	489	488	-0,48	0,963	763,5
Russian Fed	475	482	486	481	-0,11	0,974	637,0
Slovak Rep	463	482	471	472	-0,18	0,970	521,7
Slovenia	481	501	514	499	0,07	0,952	514,2
Spain	488	484	496	490	-0,19	1,000	597,9
Sweden	483	478	485	482	0,28	0,898	549,5
Switzerland	509	531	515	518	0,17	0,884	577,9
Turkey	475	448	463	462	-1,46	0,919	537,6
U.K.	499	494	514	502	0,27	0,975	756,8
United States	498	481	497	492	0,17	0,943	766,7

Source: Test scores are own calculations using the 39 countries and economies samples of the Student PISA-2012 DB. Countries average means and standard deviations have been computed as the average populations means and standard deviations of each plausible values (PV) for each domain. Further, each PV populations mean and standard deviation for each domain has been computed using Balanced Repeated Replication (BRR) (OECD, 2009). avgESCS and totINStime have been collected from PISA2012 at country level (OECD, 2013b and 2013d). (*) Variables considered refer to Q.9a and Q.9c of the School Questionnaire if PISA2012.

SECOND STAGE VARIABLE DESCRIPTION.

Regarding our second stage analysis variables, the criteria for choosing them rely on our conceptual framework (Epple and Romano, 1998; Hoxby, 2003, 2006; Ladd, 2003; Perry, 2007; Ladd and Fisk, 2009; Elacqua, 2009; Musset, 2012), which has shown us an important trade-off effect between choice and equity, in the sense that choice can influence equity in terms of social composition of students (segregation), and equity measures (school composition) can influence choice, in the sense that it can lead to different parental choice decisions (preferences) when choosing a school to attend/enroll. Therefore, depending on the educational goal pursued in terms of technical efficiency or segregation, choice mechanisms must take into consideration some specificities in terms of funding and regulation. Furthermore, we have followed what efficiency literature (Farrel, 1957; Groskhop et alter, 1978; Coelli, 2001; Alvarez Pinilla et al, 2001; Simar & Wilson, 2000 and 2007; Salinas and Santin, 2011) suggest, namely in what regards to non-controllable or environmental variables.

Variables considered for our second stage include different choice instruments, several groupings of students according to their SES level/status, and choice-equity measures as independent variables. This group of variables are depicted in table 2. Our dependent variable will be the technical efficiency scores computed with the set of variables describe before, in stage one.

Choice variables considered refer to choice instruments[22], which are normally designed/enforced by educational authorities (educational system level), namely as a policy measure, which "theoretically and empirically" have lead to different kind of effects in educational systems These group of variables are describe/presented in what follows:

(1) School Choice Availability (FreeD): It refers to the existence of school choice options, namely families are given the right to enroll in any traditional school they wish and/or government dependant and private-independent schools are legally permitted to operate and provide compulsory education. FreeD has been coded as a dummy variable being 1 if school choice exists and 0 else in each country.

(2) Enhanced school choice (Vouch): School Vouchers also referred to as scholarships, are available and applicable for each type of school; Vouch has been coded as a dummy variable being 1 if school choice exists and 0 else, in each country.

(3) Funded School Choice (MobF): Funding follows students when they leave to another school. MobF has been coded as a dummy variable being 1 if school choice exists and 0 else, in each country.

[22] As mentioned, this group of variables have been collected from the PISA2009 database for each country analysed. The fact we consider these data is that policy measures in this context change slowly in comparison to other education variables.

(4) Tuition Tax Credits: (TaxC): Tuition tax credits are available to help families offset cost of private schools. TaxC has been coded as a dummy variable being 1 if school choice exists and 0 else, in each country.

Regarding our equity measure, we have chosen the variable close related to "school composition[23]." which captures the social and economic status(SES) level of the student body attending each school. More specific, our variable is defined as the percentage of students in schools with an specific socio-economic (student) level (SEM)[24]. Three groups in terms of different social composition have been considered for each country, disadvantage, average and advantage school compositions (Table 2), which refer to:

(1) Disadvantage school socioeconomic intake (SEMddd): Is the percentage of students in schools with a disadvantage student-body SES level (schools with disadvantage socioeconomic intake), in each country.

(2) Average school socioeconomic intake (SEMavg): Is the percentage of students in schools with an average student-body SES level (schools with average socioeconomic intake), in each country.

(3) Advantage school socioeconomic intake (SEMaaa): Is the percentage of students in schools with an advantage student-body SES level (schools with advantage socioeconomic intake), in each country.

Table 2: Existence of school choice options & financial incentives: System Level & School Social Composition (SES)

Countries	FreeD	Vouch	MobF	TaxC	SEMddd	SEMavg	SEMaaa
Argentina	0	0	0	0	0,334	0,346	0,319
Australia	1	0	0	0	0,238	0,512	0,250
Austria	1	0	0	0	0,325	0,414	0,261
Belgium	1	1	0	0	0,290	0,373	0,338
Brazil	1	0	1	1	0,331	0,426	0,243
Canada	0	0	0	0	0,214	0,526	0,260
Chile	1	1	1	0	0,428	0,228	0,344
Czech Republic	1	0	1	0	0,217	0,577	0,206
Denmark	1	0	0	0	0,214	0,560	0,226
Estonia	1	1	1	1	0,190	0,581	0,229
Finland	1	0	1	0	0,160	0,670	0,170
France	1	1	1	0	0,246	0,449	0,305
Germany	1	1	0	1	0,280	0,452	0,268

[23] School composition is defined as the social composition of students who attend a school. Social composition can be measured by racial or ethnic composition of the students, or by their socio-economic status (SES). When composition of schools is measured solely by the SES of students - rather than to their race or ethnicity - normally we can refer to the term school composition as the ***mean school SES.*** PISA measures individual students' SES and then averages all the students in a school to reach a mean school SES, which means that the average is based on the actual SES of the students attending school.(Perry, 2007 and OECD, 2005)

[24] The variable we have chosen comes from the Table IV.3.7 (web), Annex B1, Chapter 3 of PISA 2012 Results: What Makes a School Successful? (Volume IV) Resources, Policies and Practices - © OECD 2013

Countries	FreeD	Vouch	MobF	TaxC	SEMddd	SEMavg	SEMaaa
Greece	1	0	0	0	0,253	0,483	0,265
Hong Kong	1	1	1	1	0,353	0,402	0,245
Hungary	1	0	1	0	0,316	0,350	0,334
Iceland	1	0	1	0	0,163	0,559	0,278
Indonesia	1	1	1	0	0,399	0,329	0,271
Ireland	1	0	1	0	0,172	0,570	0,258
Israel	1	1	0	0	0,297	0,384	0,319
Italy	1	1	0	1	0,288	0,412	0,299
Japan	1	0	0	0	0,295	0,431	0,274
Korea	1	0	0	0	0,267	0,486	0,248
Luxembourg	1	0	0	0	0,479	0,150	0,371
Mexico	1	0	0	0	0,343	0,353	0,305
Netherlands	1	0	1	0	0,234	0,509	0,257
New Zealand	1	1	0	0	0,215	0,553	0,232
Norway	1	0	0	0	0,100	0,733	0,166
Poland	1	1	1	0	0,275	0,502	0,223
Portugal	1	0	1	1	0,336	0,458	0,205
Russian Federation	1	0	0	1	0,219	0,502	0,279
Slovak Republic	1	1	1	0	0,269	0,473	0,258
Slovenia	0	0	0	0	0,295	0,402	0,303
Spain	1	1	0	0	0,295	0,429	0,277
Sweden	1	0	1	0	0,180	0,589	0,231
Switzerland	1	0	0	0	0,265	0,472	0,263
Turkey	0	0	0	0	0,320	0,431	0,248
United Kingdom	1	0	1	1	0,242	0,521	0,237
United States	1	1	1	1	0,266	0,444	0,290

Source: Regarding school choice instruments by countries we have based on Education at a Glance 2011 and Table IV.3.7; Annex B1: Results for countries and economies. PISA 2009 Results: What Makes a School Successful?: Resources, Policies and Practices (Volume 4) - © OECD 2011. As for Dummy variables take the value 1 if characteristic holds and zero otherwise. As for Social Composition of Schools we have based on Table IV.3.7 (web), Annex B1, Chapter 3 of PISA 2012 Results: What Makes a School Successful? (Volume IV) Resources, Policies and Practices - © OECD 2013

In order to capture the combined effect of school choice and equity we have chosen the product of school choice variables with school composition. This indicator (variable) will provide information of the effect of equity when school choice is applicable. The interest of our research is focused in this group of variables, which aim at uncover the effects of school composition-choice mechanisms over school (technical) efficiency, by clearly identifying if these effects are related to social composition or the results of competition.

Choice-equity variables are described in what follows.

- Parental Freedom: PaF = FreeD x SEM_
- Enhanced School Choice: EnSC = Vouch x SEM_
- Permanent School Choice: PsC = MobF x SEMaaa
- Tuition_Tax_Credits_School Choice: TsC = TaxC x SEM_

As we have considered three groups in terms of different social composition SEMaaa (advantage), SEMavg (average) and SEMddd (disadvantage), there will be three sets of choice-equity indicators for each group. This is 12 variables, 4 for each group.

As mentioned, in order to capture the "composite effect" of choice and equity, these school choice variables have been multiplied by the percentage of students (net intake) in schools with a disadvantage, average and advantage school composition, allowing us to build-up twelve new variables. (a) 3 variables for Parental Freedom (PaF), referring to the existing choice for parents/students in schools with "disadvantage, average and advantage socioeconomic student intake" (b) 3 variables for Enhanced School Choice, (EnSC) referring school voucher availability and applicable choice for parents/students in schools with " disadvantage, average and advantage socioeconomic student intake", (c) 3 variables for Permanent School Choice (PsC), where funding (vouchers within the school year) follows students, and are applicable to parents/students in schools with " disadvantage, average and advantage socioeconomic student intake", and (d) 3 variables for Tuition Tax Credits (TsC), which refer to existing tax credits for parents/students in schools with "disadvantage, average and advantage socioeconomic student intake".

Last, the dependent variable in this second stage refers to the technical efficiency scores for each country of our sample (CRST), this is, the Technical Efficiency Scores measured for each "representative school" at country aggregated level. As mentioned before, radial technical efficiency scores have been computed considering an output oriented perspective and constant returns to scale.

METHODOLOGY AND EMPIRICAL STRATEGY

Our research will encompass a two stage analysis: First, in the framework of a simple production function we will measure technical (in)efficiency of schools (at country level) by considering a bundle (or well grouped) of “controllable” inputs (student SES, the percentage of full time teachers certified and weekly time spent for learning in reading, math and science) and outputs, for which student achievement has been considered, measured by the average of each countries standardize reading, math and science test scores, and second, our interest lies in understanding the effects of discretionary or non-controllable variables, for which choice and balanced choice-equity schemes have been considered, over efficiency scores.

To this end, and due the unawareness of the technology used in the educational process, the most suitable technique deals with non parametric Data Envelope Analysis (DEA), as it measures technical efficiency (scores) and is characterized by the fact that it does not impose a specific functional form of the production function (frontier), but rather establishes certain assumptions about the properties of technology (especially those related to convexity and monotonicity) which allow the definition of the set of feasible productive processes whose frontier envelops the observed data. Moreover, as our interest deals on how to assess efficiency by means of non-discretionary or non-controllable variables, in a second stage, we implement truncated regressions, a type of dependant variable modeling technique for which some

of the observations are not included in the analysis, where we will regress choice and balanced school choice-equity measures over the efficiency scores previously estimated.

The DEA Framework (First Stage Analysis)

DEA, originating from Farrell (1957) seminal work and popularized by Charnes, Cooper and Rhodes (1978), assumes the existence of a convex production frontier. This frontier in the Data Envelope Analysis (DEA) approach is constructed using linear programming methods, the term "envelopment" stemming from the fact that the production frontier envelops the set of observations[25].

DEA allows the calculation of technical efficiency measures that can be either input or output oriented. The purpose of an output-oriented study is to evaluate by how much output quantities can be proportionally increased without changing the input quantities used, which has been the traditional perspective taken in most of the papers addressing this issue (Afonso et al, 2005; among others). The perspective will be adopted in this paper moreover, we will assume a technology *with variable returns to scale (VRS)*.

The analytical description of the linear programming problem to be solved, output oriented and assuming variable returns to scale hypothesis[26], is sketched below. The standard formulation of the program can take several forms according to different criteria, so it can be oriented to minimize input values or maximize output values and can also be presented as a fractional linear or dual program. For our purpose, we adopt an output-oriented program with variable returns to scale (Banker et al, 1984)

$$Max\ \theta_0 + \varepsilon\left(\sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+\right)$$

$$st. \sum_{r=1}^{s} \lambda_j y_{rj} - s_r^+ = \theta_0 y_{rj0}\ \forall r = 1....s$$

$$\sum_{j=1}^{n} \lambda_j x_{ij} + s_i^- = x_{ij0}\ \forall i = 1....m$$

$$\sum_{j=1}^{n} \lambda_j = 1$$

[25] Coelli, Rao and Battese (1998) and Thanassoulis (2001) offer good introductions to the DEA methodology. More detail giving a nice overview of measuring efficiency and productivity (including both parametric and non-parametric techniques), can be enhanced in Simar, L. and Wilson, P. (2001), Coelli and Perelman, 2001, Perelman and Santin, 2005, and Alvarez Pinilla (eds), 2001.

[26] To this point we have to say that one of the biggest problems underlying this methodology is that of the worthwhileness of the estimated efficiency scores. This problems entail (Simar and Wilson, 2007), both a scarce (if any) coherent description of the DGP and the fact that efficiency scores are serially correlated. To this end, in order to overcome these problems, we follow Simar and Wilson (2007- Algorithm 1) DGP procedure sensible and consistent with our methodology.

$$\lambda_j \geq 0 \; \forall j = 1 \ldots . n$$

$$s_r^+ \geq 0; \; s_i^- \geq 0$$

where x_{ij} is the vector of inputs and y_{rj} is the vector of outputs for DMU j; θ_0 is the efficiency score, ε is an infinitesimal non-Archimedean constant, λ_i are the weightings and s_i^- and s_r^+ are the inputs slacks and outputs slacks, respectively. If the score equals one the producer is fully efficient relative to other units. If the score is lower than one, the unit evaluated is inefficient as the sample contains other units which perform better.

Environmental variables (Second Stage Analysis)

The standard DEA models as the one described in (1) incorporate only discretionary inputs, those whose quantities can be changed (or controlled) by the DMU and do not take into account the presence of environmental variables or factors, also known as nondiscretionary inputs. However, socio-economic or governance differences may play a relevant role in determining heterogeneity across DMUs – either secondary schools, universities or countries' achievements in an international comparison – and influence educational outcomes. These exogenous factors can include, for instance, school choice measures or school autonomy regulation. As non-discretionary and discretionary inputs jointly contribute to each DMU outputs, there are in the literature several proposals on how to deal with this issue, implying usually the use of two-stage and even three or four-stage models[27].

In this second stage, our main locus is to assess the impact of choice and choice-equity variable over school efficiency. Let Z_i be a (1×r) vector of our non-discretionary outputs, in our case, Parental Freedom (PaF), Enhanced School Choice (EnSC), Funded School Choice (FsC), Tuition Tax Credits (TsC) and school socioeconomic intakes (SEM). In a typical two-stage approach, the following regression is estimated:

$$\widehat{\delta_i} = z_i\beta + \varepsilon_i, \text{where } \varepsilon \backslash z \sim N(0, \sigma^2) \qquad \textbf{(2)}$$

Where $\widehat{\delta_i}$ is the efficiency score that resulted from stage one, - i.e. from solving (1). β is a (r×1) vector of parameters to be estimated in step two associated with each considered non-discretionary input. The parameters of equation (2) are usually estimate with a truncated regression, as the values of efficiency scores are truncated at some point, although others have used OLS[28].

[27] See Fried y Lovell (1996), Fried et al. (1999), Fried et al. (2002), Cordero Ferrera et al (2011), Ruggiero (2004) and Simar and Wilson (2007) for an overview

[28] See Simar and Wilson (2004) for an extensive list of published examples of the two step approach. In what concerns education, Kirjavainen and Loikkanen (1998), Afonso and St. Aubyn (2005) and Agasisti, (2009) are some good examples of a two stage DEA-Efficiency Analysis considering non-discretionary variables (DEA/using Censured Tobit approach).

However, these group of standard models (Ray, 1991; McCarty and Yaisawarng, 1993) have been criticize arguing that efficiency scores computed in stage 1 are serial correlated (Xue and Harker, 1999) thus errors from equation (2) violate the independence hypothesis leading to bias estimations. To this end, recent research undertaken by Simar and Wilson (2007) provide a procedure to overcome this limitation based on bootstrap techniques, allowing to correctly (unbiased) estimate the parameters. These authors have develop two algorithms that can be used in second stage efficiency analysis which provide valid statistical inference (Cordero Ferrera et al,. 2010). For our purpose, mention that from a Monte-Carlo experiment conducted by Simar and Wilson, they conclude that between both algorithms, the second performs better when the sample size increases, whereas, algorithm 1overcomes algorithm 2 if the sample is small (Simar and Wilson, 2007, pp.50-51 as cited by Cordero Ferrera et al, 2010). Hence, in our second stage we will implement algorithm 1 as suggested by Simar and Wilson (2007).

Algorithm 1 is as follows:

1. The computation of θ_j for all n decision units using original data.

2. Use the method of maximum likelihood to obtain an estimate $\hat{\beta}$ of β as well as an estimate $\hat{\sigma}_u$ of σ_u from $\hat{\theta}_j = f(z_j, \beta) + u_j$, considering it is a truncated regression.

3. The computation of L (L = 2000) bootstrap estimates for β and σ_u in the following way:

3.1. For each j=1 . . . n, draw u_j from the N(0, $\hat{\sigma}_u$) distribution with left-truncation at 1-$z_j\hat{\beta}$.

3.2. Compute $\theta_j^* = z_j\hat{\beta} + u_j$ again for each j = 1 . . . n.

3.3. Use the maximum likelihood method to estimate the truncated regression of θ_j^* on z_j, yielding a bootstrap estimates $(\hat{\beta}^*, \hat{\sigma}_u^*)$

4. Use the bootstrap values and the original estimates$\hat{\beta}$ and $\hat{\sigma}_u$ to construct estimated confidence intervals for each element of β and σ_u.

RESULTS AND DISCUSSION

Results achieved are presented following our two stage analysis. This is, first we present the 39 efficiency scores achieved by implementing a DEA technique[29]. Second, we present results achieved of estimating our truncated regression using algorithm 1 proposed by Simar and Wilson (2007), between choice and choice-equity schemes over the efficiency test scores, which answer each of our research hypothesis stated in section 1. Results are the followings.

Stage 1. DEA Results: Cross-country Efficiency Scores

The measurement results of static inefficiency using our DEA model for country schools are shown in the table 3. Scores for 2012 are presented. Variable returns to scale (VRS) (in) effi-

[29] To compute the technical efficiency scores we have used the Data Envelope Analysis (computer) Program (DEAP) Version 2.1 develop by Professor Tim Coelli of the Centre for Efficiency and Productivity Analysis (CEPA) of the University of Queensland. http://www.uq.edu.au/economics/cepa/

ciency index shows the relative distance of each decision unit (country level school) to the optimal frontier built with a VRS technology. A value of 1.000 represents no inefficiency and schools (at country aggregated level) stand on the optimal frontier. The overall (in) efficiency scores have a mean value of 0,93 with a standard deviation of 0,075 of the "Production Set (Frontier)".

As for the top-lower efficiency country-schools performers we observe that top-performers in general have achieve better academic results, a fact that assumes optimal use of resources. Educational systems from European and Asian countries (Finland, Estonia, Austria, Korea, Hong Kong and the Netherlands) stand out among all the countries analyzed. Regarding the lower-performers include those education systems of the countries of Latin America (México, Argentina, Brazil or Chile). This difference may be justified in part from a relative scarcity of resources, especially in the number of teachers or less training time devoted to core subjects. Further, it could also come from lower own and peers' SES level in these countries (Hanushek, 1986, 2003)

Table 3: VRS Efficiency Scores

Countries	Efficiency Scores
Argentina	0,731
Australia	0,935
Austria	1,000
Belgium	0,938
Brazil	0,796
Canada	0,992
Chile	0,812
Czech Republic	1,000
Denmark	0,937
Estonia	1,000
Finland	1,000
France	0,925
Germany	0,979
Greece	0,860
Hong Kong-China	1,000
Hungary	0,937
Iceland	0,913
Indonesia	0,725
Ireland	0,977
Israel	1,000
Italy	0,899
Japan	0,999
Korea	1,000
Luxembourg	0,917
Mexico	0,793

Countries	Efficiency Scores
Netherlands	1,000
New Zealand	0,958
Norway	0,935
Poland	0,993
Portugal	0,990
Russian Federation	0,990
Slovak Republic	0,889
Slovenia	0,945
Spain	0,906
Sweden	1,000
Switzerland	0,965
Turkey	0,882
United Kingdom	0,917
United States	0,935

Source: Own elaboration based on PISA2012 data (Aggregated country level). Efficiency scores have been computed using DEAP software (V.2.1)

4.2. Stage 2. Impact of choice and choice-equity measures in country (school) efficiency

Our first and second hypothesis focuses on assessing the effects of both school choice schemes solely and in a combined manner with an equity dimension. Results are depicted in table 4.

The overall results show that school choice schemes solely; school choice availability (FreeD) and enhanced school choice (Vouch) have no effects over efficiency scores. This is, these variables are not statistically different from zero. The latter if surprising, it can be considered as expected in accordance to recent literature findings (Waslander et al, 2010, Belfield and Levin, 2001). Therefore, we can assume that by not finding effects of parental freedom (enhancing choice alternatives between public, private-dependent and private independent) over school efficiency no effective competition exist derived from the implementation of choice and financial mechanisms. This situation, according to the existing literature (Epple and Romano, 1998; Ladd, 2003) could lead to potential segregation effects (Ladd, 2003) as probably affluent parents will be those who benefit from them. However, we can´t say anything about school efficiency or even competition effects influencing school efficiency, as no clear effects have been achieved.

Regarding the combined choice-equity instruments, namely Parental Freedom (FreeD) shows positive effects. Having in mind that our build-up indicators provide a measure of "choice applicable to the percentage of students in schools where pupils are not over or under represented by advantage or disadvantage Socio Economic Status (SES) students, but instead are applicable to school average SES background, our results then, can be considered as dealing with "segregation problems" by providing "controlled choice instruments". Thus, the positive

effects can be argued as reasonable in the sense that "on average" when choice and equity measures are applicable, school response focuses in attracting the correct combination which leads to achieve "the average SES student-intake" in order to benefit from the different existing measures. Moreover, given the fact that student achievement and SES status of a student's peers are strongly related, choice arrangements that increase integration are likely to increase student achievement as all students throughout the school can benefit from higher achieving classmates (Hanushek et al, 2003), thus leading to an increase on average of country school-efficiency. Furthermore, schools facing the right incentives (Elacqua, 2009) have the potential to more appropriately deal with problems by the allocation effects of choice and are induced to rise their efficiency (Ladd, 2002) meeting parental demands of school quality, by increasing achievement.

Table 4: Choice-Equity Over Efficiency by SES School Composition

Bootstraps Estimation (Algorithm 1): Second stage Analysis				
Independent Variables	**MODEL 1**	**Option A**	**MODEL 2**	**Option B**
	Choice Solely	**Choice and Equity: DISADVANTAGE**	**Choice and Equity: AVERAGE**	**Choice and Equity: ADVANTAGE**
Freedom (FreeD)	0,0598291			
	(0,301)			
Vouchers (Vouch)	-0,0233771			
	(0,399)			
Fund_Follow (MobF)	-0,0088468			
	(0.716)			
TuitionTax_Credits (TaxC)	0,0188894			
	(0,560)			
Freedom&Equity (PaF)		-0,0169778	**0,169234**	0,0902255
		(0,920)	***(0,0528)***	*(0,668)*
Vouchers&Equity (EnSC)		-0.074431	-0,0145239	-0,0901703
		(0,477)	*(0,793)*	*(0,400)*
Fund_Follow Students & Equity (PsC)		-0,0743464	-0,0080834	-0,0456536
		(0,481)	*(0,851)*	*(0,623)*
Tax_Credits&Equity (TsC)		0,0975777	-0,0274439	0,0886703
		(0,430)	*(0.657)*	*(0,463)*
Constant	0,8875	0,9478337	0,8632613	0,9208974
	(0.000)	*(0.000)*	*(0.000)*	*(0.000)*
/Sigma	0,0717867	0,0721552	0, 0681748	0,0730049
	(0.000)	*(0.000)*	*(0.000)*	*(0.000)*

Source: Own calculations based on OECD-PISA2012 Country level Data. The dependant variable is the Radial Efficiency Scores (in the case of variable returns to scale and output oriented). Bootstraps estimations following Simar and Wilson (2007 Algorithm 1). P-Values in cursive.

Thereby, it is worth noting that these results can also be seen as aligning incentives by noticing that school behavior in what "competing for student's characteristics" turns out to be more

efficient in terms of equity when fixing our choice mechanisms in terms of "average SES school composition (or background). As a matter of fact, when running the same choice-equity variables considering "(a) disadvantage or (b) advantage SES student intake"over the technical efficiency scores, no results have been found.

FINAL REMARKS AND CONCLUSIONS

From a theoretical point of view, we can argue that school choice schemes targeting inequality (less segregation), by ensuring greater freedom of choice to students in schools meeting the average SES level of student composition in their classrooms (equitable admission and allocation), will lead to improved school efficiency (effective use of resources - namely over organization of instruction issues) in order to meet parental demand for "school quality".

Our results achieved suggest that effects of choice and choice-equity mechanisms vary. As for choice measures solely no concluding evidence was found (answering our first hypothesis). These results despite somehow striking can be associated general findings from exiting literature. Therefore, we observe that competition effects driven by school choice alone are not conclusive over school efficiency.

In contrast, when considering combined choice-equity measures, positive effects accrue when parents/students have the right to enrol in any school of their choice. Nevertheless, we have to say that these results are only applicable specifically to the percentage of students in schools having an average SES level (student-intake) of student composition in their schools. These facts suggest that efficiency gains of schools can be driven by controlling social compositions of schools (and answering our second hypothesis).

Policies aiming at improve school efficiency limiting segregation problems should focus in both, fixing the "average SES school composition" and providing more choice to parents.

REFERENCES

Abdulkadiro, A., et al. (2006), "*Changing the Boston School Choice Mechanism*", NBER Working Paper No. 11965.

Adams, R and Wu, M. (2002): *Programme for International Student Achievement: Technical Report.* OECD. Paris.

Afonso, A. and St. Aubyn, M. (2006) *Cross-country Efficiency of Secondary Education Provision: a Semi-parametric Analysis with Non-discretionary Inputs*, Economic Modelling, vol. 23 (3), pp. 476-491

Agasisti, T. (2009) *The efficiency of Italian secondary schools and the potential role of competition: A Data Envelopment Analysis using OECD-PISA2006 data,* Department of Management, Economics and Industrial Engineering, Politecnico di Milano.

Álvarez Pinilla, A (Eds) (2001), *La Medición de la Eficiencia y la Productividad*. Pirámide, Madrid.

Angrist, J. and K. Lang (2004), "*Does School Integration Generate Peer Effects?* Evidence from Boston‟sMetco Program", Discussion Paper No. 976, IZA.

Banker, R, D., Charnes, A. and Cooper, W. W. (1984) *Models for estimating technical and scale efficiencies in data envelopment analysis*, Management Science 30(9), 1078.

Banker, R.D., Johnston, H.H., (1994). Evaluating the impacts of operating strategies on efficiency in the US airline industry. In: Charnes, A., Cooper, W.W., Levin, A.Y., Seiford, L.M. (Eds.), *Data Envelopment Analysis: Theory Methodology and Application*. Kluwer Academic Publishers, Inc., Boston, pp. 97–128.

Battese, G.E. and Coelli, T.J. (1995). *A model for technical inefficiency effects in a stochastic production function for panel data.* Empirical Economics 20, 325–332.

Belfield, C. and Levin, H. (2001) *The Effects of Competition on Educational Outcomes: a Review of the U.S. Evidence*, Occasional Paper 25, Teachers College, National Center for the Study of Privatization in Education, Columbia University.

Belfield, C. and Levin, H. (2002), *The Effects of Competition between Schools on Educational Outcomes: a Review for the United States*, Review of Educational Research, Vol. 72, N°2.

Betts, J.R. (2005) "The Economic Theory of School Choice" Chapter 2 in Julian R. Betts and Tom Loveless (Eds.) *Getting Choice Right: Ensuring Equity and Efficiency in Education Policy*, Washington, D.C.: Brookings Institution Press, pp. 14-39.

Betts, J.R. and Loveless, T. (2005) *Getting Choice Right: Ensuring Equity and Efficiency in Education Policy*, Betts, J.R. and Loveless, T. (Eds.), Washington, D.C.: Brookings Institution Press

Bifulco, Ladd and Ross, (2007). "*Public School Choice and Integration: Evidence from Durham, North Carolina,*" Working papers 2007-41, University of Connecticut, Department of Economics, revised Jun 2008.

Boardman, A.E. and Murnane, R. J. (1979) *Using Panel Data to Improve Estimates of the Determinants of Educational Achievement*, Sociology of Education, Vol. 52, No. 2 (Apr., 1979), pp. 113-121

Bryk, A.S. and Thum, Y.M. (1989) *The effects of high school organization on dropping out: An exploratory investigation.* American Educational Research Journal (26), pp.353-383.

Card, D. and Kreuger, A., (1990). *Does school quality matter? Returns to education and the characteristics of public schools in the United States*, NBER Working Paper Series No. 3358

Charnes, A., Cooper, W.W., Rhodes, E., 1978. *Measuring the inefficiency of decision making units.* European Journal of Operational Research 2, 429–444.

Chubb, J. E. & Moe, T. M. (1990). *Politics, Markets, and America's Schools.* Washington, D.C.: Brookings Institution.

Coelli, T. y Perelman, S., (2001). Medición de la Eficiencia Técnica en Contextos Multiproducto. In: Álvarez Pinilla, A. (Ed.), *La Medición de la Eficiencia Productividad*. EditorialPirámide, Madrid.

Coelli, T., Rao, D.S.P., Battese, G.E., (1998). *An Introduction to Efficiency and Productivity Analysis*. Kluwer Academic Publishers, Inc., Boston.

Cohn, E and Geske, T.G. (1990) *The Economics of Education* (Oxford, Pergamon Press)

Coleman, J. S., Campbell, E., Hobson, C., McPartland, J., Mood, F., Weinfeld, F., & York, R. (1966). *Equality of educational opportunity*. Washington, D.C.: U.S. Government Printing Office.

Coleman, J. S., Campbell, E., Hobson, C., McPartland, J., Mood, F., Weinfeld, F., & York, R. (1966). *Equality of educational opportunity*. Washington, D.C.: U.S. Government Printing Office.

Cordero JM, Crespo E, Pedraja F y Santín D. (2011) Exploring educational efficiency divergences across Spanish regions in PISA 2006. Revista de Economia Aplicada 57:117–145

Cordero, J.M., Pedraja, F. and Santín, D. (2009) Alternative approaches to include exogenous variables in DEA measures: A comparison using Monte Carlo, in Computers & Operations Research 36 (2009), pp. 2699--2706

Cordero-Ferrera J.M. , Pedraja-Chaparro, F. and Santín, D. (2010) Enhancing the inclusion of non-discretionary inputs in DEA, in Journal of the Operational Research Society (2010) 61, 574 --584

Cordero-Ferrera, J.M.; Pedraja- Chaparro, F. y Salinas-Jiménez, J. (2008), *Measuring efficiency in education: an analysis of different approaches for incorporating non-discretionary inputs*, Applied Economics, 40

Crespo-Cebada, E., Pedraja-Chaparro, F. and Santín, D. (2014) Does school ownership matter? An unbiased efficiency comparison for regions of Spain, in Journal of Productivity Analysis (2014) 41:153–172

Crozie et al (2008) *White Middle-class Parents, Identities, Educational Choice and the Urban Comprehensive School: Dilemmas, Ambivalence and Moral Ambiguity*. British Journal of Sociology of Education, Vol. 29 N° 3.

Cullen, J., Jacob, B. and Levitt, S. (2000) *The Impact of School Choice on Student Outcomes: An Analysis of the Chicago Public Schools*, NBER Working Papers N°7888, National Bureau of Economic Research

Daraio, C. and Simar, L. (2005). Introducing environmental variables in nonparametric frontier models, in E. Goldring (Eds), *School Choice and School Improvement,* Havard Education Press, Cambridge.

Denessen, E., Sleegets, P. and Smit, F. (2001), *Reasons for School Choice in the Netherlands and in Finland*, Occasional Paper No° 24, National Center for the Study of Privatization in Education, Teachers College, Columbia University.

Dronkers, J. and P. Robert (2003), *The Effectiveness of Public and Private Schools from a Comparative Perspective*, N° EUI Working Paper N° 2003-13, European University Institute.

Ehlers, L. (2010), *"School Choice with Control"*, Working paper, Department of Economics and CIREQ, Université de Montréal.

Elacqua, G. (2009), *"The impact of school choice and public policy on segregation: Evidence from Chile",* Centro de Politicas Comparadas de Educación, Universidad Diego Portales, Santiago, Chile

Epple, D. and Romano, R.E. (1995) Public School Choice and Finance Policies, Neighborhood Formation, and the Distribution of Educational Benefits. Working paper, University of Florida, July 1995.

Epple, D. and Romano, R.E. (1998) Competition between Private and Public Schools, Vouchers, and Peer-Group Effects, The American Economic Review, Vol. 88, No. 1 (Mar., 1998), pp. 33-62

Epple, D., Elizabeth, N. and Romano, R.E. (1997) Ability Tracking, School Competition, and the Distribution of Educational Benefits. Working paper, Carnegie Mellon University, February 1997

Färe, R., 1988. *Fundamentals of Production Theory*.Springer, Berlin.

Färe, R., Grosskopf, S., Lovell, C.A.K., 1985. *The Measurement of Efficiency of Production.* Kluwer- Nijhoff Publishing, Boston.

Farrell, M. (1957). *The measurement of productive efficiency*. Journal of the Royal Statistical Society, Series A 120, 253–281.

Feinberg, W., and Lubienski, C. (Eds.). (2008). *School Choice Policies and Outcomes*. Albany: State University of New York Press.

Fried, H.O., Lovell, C.A. and Yaisawarng, S. (1999) Incorporating the Operating Environment into Non-Parametric Measure of Technical Efficiency, in Journal of Productivity Analysis 12(3), pp.249-267.

Fried, H.O., Lovell, C.A., Schmidt, S.S. and Yaisawarng, S. (2002) Accounting for Environmental Effects and Statistical Noise in DEA, in Journal of Productivity Analysis (17), pp. 157-174, 2002.

Friedman, M. (1955 & 1962), *"The Role of Government in Education",* Economics and the Public Interest, Rutgers University Press, New Brunswick, NJ.

Gamoran, A. (1996) *Student achievement in public magnet, public comprehensive, and private city high schools.* Educational Evaluation and Policy Analysis (18), pp. 1-18.

Gamoran, A. and Long, D.A. (2006) *Equality of Educational Opportunity: A 40-Year Retrospective,* WCER Working Paper No. 2006-9, December, 2006.

Glenn, C. (1999), "*Why are Progressives so Hostile to School Choice Policies?*", Current Issues in Comparative Education, Teachers College, Columbia University, Vol.1 N° 2.

Glenn, C.L. (1989) *"Choice of School in Six Nations: France, Netherlands, Belgium, UK, Canada, West-Germany*, US Department of Education, Washington D.C.

Goldhaber, D. & Brewer, D. (1997). *Why don't schools and teachers seem to matter? Assessing the impact of unobservable on educational productivity.* Journal of Human Resources, 33, 505-523.

Goldhaber, D. (1996) *Public and Private High Schools: Is School Choice an Answer to the Productivity Problem?*, Economics of Education Review (15), 93-109.

Grosskopf, S.; Hayes, K.; Taylor, L. y Weber, W. (1997) *Budget-constrained frontier measures of fiscal equality and efficiency in schooling*, Review of Economics and Statistics, 79 (1) pp.116-124.

Hanushek E., J. Kain, and S. Rivkin (2004), *"Why Public Schools Lose Teachers,"* Journal of Human Resources Vol. 39, No. 2.

Hanushek et al (1996), "*Aggregation and the Estimated Effects of School Resources*", NBER Working Paper 5548

Hanushek, E (1986). *The economics of schooling: Production and efficiency in public schools*. Journal of Economic Literature, 24 (3), 1141-1177.

Hanushek, E. (2002), "Evidence, politics, and the class size debate", in L. Mishel and R. Rothstein (eds.), *The Class Size Debate*, Economic Policy Institute, Washington DC, pp. 37-65.

Hanushek, E. and S. Rivkin (2005), "Does Public School Competition Affect Teacher Quality?" in Hoxby C., *The Economics of School Choice*, the University of Chicago Press, Chicago. EDU/WKP(2012)347

Hanushek, E. et al (2003) *"Does Peer Ability Affect Student Achievement?"*, Journal of Applied Econometrics.

Hanushek, E.A. (1989). *The impact of differential expenditures on school performance.* Educational Researcher, 18, 45-62.

Hanushek, E.A. and Woessmann, L. (2007) *The Role of Education Quality for Economic Growth*. Policy Research Working Paper WPS4122, World Bank, Washington, DC.

Hastings, J., Kane, T. and Staiger, D. (2005) *Parental Preferences and School Competition: Evidence from a Public School Choice Program*, NBER Working Paper No.11805, National Bureau of Economic Research.

Hastings, J., Kane, T. and Staiger, D. (2006), *Preferences and Heterogeneous Treatment Effects in a Public School Choice Lottery*, NBER Working Paper No.12145, National Bureau of Economic Research.

Hoxby, C M. (2000), *"Does Competition among Public Schools Benefit Students and Taxpayers?*", The American Economic Review, Vol. 90, No. 5 (Dec., 2000), pp. 1209-1238

Hoxby, C. (2003a), "*School Choice and School Productivity: Could School Choice Be a Tide that Lifts All Boats?"*, in Hoxby C., The Economics of School Choice, the University of Chicago Press, Chicago.

Hoxby, C. (2003b) "*School choice and school competition: Evidence from the United States*", Swedish Economic Policy Review, No. 10, pp. 11-67.

Hoxby, C. (2006), *"School Choice: The Three Essential Elements and Several Policy Options"*, Keynote Speech Delivered on 30 June 2005 to the New Zealand Association of Economists, Christchurch, New Zealand, Education Forum.

Hoxby, C. M. (1999) *"The productivity of schools and other local public goodsproducers"*, Journal of Public Economics 74, pp. 1–30

Julian R. Betts, (2005), "The Economic Theory of School Choice" Chapter 2 in Julian R. Betts and Tom Loveless (Eds.) *Getting Choice Right: Ensuring Equity and Efficiency in Education Policy*, Washington, D.C.: Brookings Institution Press, pp. 14-39.

Kirjavainen, T., Loikkanen, H.A., (1998). *Efficiency differences of Finnish senior secondary schools: an application of DEA and tobit analysis*. Economics of Education Review 17, 377–394.

Ladd, H. (2002). "*School Vouchers: A Critical View,*" Journal of Economic Perspectives, American Economic Association, vol. 16(4), pages 3-24, Fall.

Ladd, H. (2003), *"Comment on Caroline M. Hoxby: School Choice and School Competition: Evidence from the United States"*, Swedish Economic Policy Review n°10.

Ladd, H. (2008), "*Reflections on Equity, Adequacy and Weighted Student Funding"*, Education Finance and Policy, Vol. 3 N° 4.

Ladd, H. and E. Fiske (2001*), "The Uneven Playing Field of School Choice: Evidence from New Zealand"*, Journal of Policy Analysis and Management, Vol. 20.

Ladd, H. and E. Fiske (2003), "*Does Competition Improve Teaching and Learning? Evidence from New Zealand"*, Educational Evaluation and Policy Analysis, Vol. 25 N°1.

Ladd, H. and E. Fiske (2009), "*The Dutch Experience with Weighted Student Funding: Some Lessons for the U.S."*, Working Paper N° 3, Working Papers Series, Duke University.

Ladd, H. and Fiske, E. (2001) *The Uneven Playing Field of School Choice: Evidence from New Zealand*, Journal of Policy Analysis and Management, Vol. 20.

Ladd, H. and Walsh, Randall P. (2002) "*Implementing value-added measures of school effectiveness: getting the incentives right,*" Economics of Education Review, Elsevier, vol. 21(1), pages 1-17, February.

Ladd, H., E. Fiske and N. Ruijs (2011), "Does Parental Choice Foster Segregated Schools? Insights from The Netherlands" in Berends M., M. Cannata and E. Goldring (Eds), *School Choice and School Improvement*, Havard Education Press, Cambridge.

Leibenstein, H. (1966). "*Allocative efficiency and x-efficiency*" American Economic Review, 56, 392-495.

Levin, H. (1974). "*Measuring efficiency in educational production."* Public Finance Quarterly, 2, 3-24.

Levin, H. (1976) Concepts of Economic Efficiency and Educational Production, in Joseph T. Froomkin, Dean T. Jamison and Roy Radner (eds), *Education as an Industry*, NBER, pp. 149 - 198

Levin, H. (1994). *Production functions in education.* In T. Husen and T. N. Postlethwaite (Eds.), International Encyclopedia of Education (pp.4059-4069). New York: Pergamon.

Levin, H. (2009). An Economic Perspective on School Choice, in Berends, M., G. Springer, M., Ballou, D. and Walberg, H. (Eds.), *Handbook of Research on School Choice*. Routledge, Taylor and Francis Group Publishers, pp. 19-34 (Chapter 2).

Lubienski, C. (2009), *"Do Quasi-markets Foster Innovation in Education?: A Comparative Perspective",* OECD Education Working Papers, No. 25, OECD Publishing. http://dx.doi.org/10.1787/221583463325

McCarty, T.A., and Yaisawarng, S. (1993) *Technical efficiency in New Jersey school districts.* The measurement of productive efficiency: Techniques and applications, pp. 271-287.

McEwan, P. and Carnoy, M. (2000) *The Effectiveness and Efficiency of Private Schools in Chile's Voucher System*, Educational Evaluation and Policy Analysis, Vol. 33.

Moreno, J. and Santín D. (2010) *Determinantes de la eficiencia educativa en la Unión Europea.* Hacienda pública española(193), 131-155.

Murnane, R.J. (1981) *Interpreting the evidence on school effectiveness.* Teachers College Record (83), pp.19-35.

Musset, P. (2012), *"School Choice and Equity: Current Policies in OECD Countries and a Literature Review"*, *OECD Education Working Papers*, No. 66, OECD Publishing. http://dx.doi.org/10.1787/5k9fq23507vc-en

Nechyba, T. (2003), "*School finance, spatial income segregation, and the nature of communities*", Journal of Urban Economics, Vol. 54.

OCDE (2009): "PISA Data Analysis Manual SPSS® SECOND EDITION", Paris,

OECD (2006), *Demand-Sensitive Schooling? Evidence and Issues*, OECD, Paris.

OECD (2007), *No More Failures. Ten Steps to Equity in Education,* OECD, Paris.

OECD (2007): "No More Failures. Ten Steps to Equity in Education", OECD, Paris.

OECD (2008), *Measuring Improvements in Learning Outcomes: Best Practices to Assess the Value-Added of Schools,* OECD, Paris.

OECD (2010a), *PISA 2009 Results: Overcoming Social Background: Equity in Learning Opportunities and Outcomes* (Volume II), OECD, Paris.

OECD (2010b), *PISA 2009 Results: What Makes a School Successful?: Resources, Policies and Practices* (Volume IV), OECD, Paris.

OECD (2010c), *Closing the Gap for Immigrant Students: Policies, Practice and Performance,* OECD Reviews of Migrant Education, OECD, Paris.

OECD (2011), *Education at a Glance 2011: OECD Indicators*, OECD, Paris.

OECD (2013a), *PISA 2012 Assessment and Analytical Framework: Mathematics, Reading, Science, Problem Solving and Financial Literacy*, OECD Publishing.

OECD (2013b), *PISA 2012 Results: Excellence Through Equity: Giving Every Student the Chance to Succeed* (Volume II), PISA, OECD Publishing. (Preliminary version)

OECD (2013c), *PISA 2012 Results: Ready to Learn – Students' Engagement, Drive and Self-Beliefs* (Volume III), PISA, OECD Publishing. (Preliminary version)

OECD (2013d), *PISA 2012 Results: What Makes Schools Successful? Resources, Policies and Practices* (Volume IV), PISA, OECD Publishing.

OECD (2014), *PISA 2012 Results: What Students Know and Can Do – Student Performance in Mathematics, Reading and Science* (Volume I, Revised edition, February 2014), PISA, OECD Publishing.

OECD (2012a): "PISA 2009 Technical Report", PISA, OECD Publishing.

OECD (2012b): "Education at a Glance 2012": OECD Indicators, OEDC Publishing.

Perelman, S. and Santín, D. (2008) *Measuring educational efficiency at student level with parametric stochastic distance functions: an application to Spanish PISA results*, Education Economics, Vol. 19 (1), February 2008, pp. 29-49

Perry, L. (2007), *School composition and Student Outcomes: A Review of Emerging Areas of Research*, Referred paper presented at the annual conference of the Australian Association for Research in Education, Nov. 2007 in Fremantle, WA.

Raveaud, M. and Zanten, A.V. (2007) *Choosing the local school: middle class parents" values and social and ethnic mix in London and Paris*. Journal of Education Policy, Vol. 22 N° 1.

Ray, S.C. (1991) *Resource-use efficiency in public schools: A study of Connecticut data*. Management Science, 37(12), 1620-1628.

Ruggiero, J. (2004). Performance evaluation in education: modeling educational production. In: Cooper, W.W., Seiford, L.M., Zhu, J. (Eds.), *Handbook on Data Envelopment Analysis*. Kluwer Academic Publishers, Boston, pp. 265–298 (Chapter 10).

Rumberger, R. W. & Palardy, G. J. (2004). Multilevel models for school effectiveness research. In D. Kaplan (Ed.), *Handbook on quantitative methodology for the social sciences* (pp. 235-258). Thousand Oaks, CA: Sage

Salinas, F. J. and Santín, D. (2011) Are you on the educational production frontier? Some economic insights on efficiency from PISA. pp. 169-182. In Pereyra, M.A., Hans-Georg Kotthoff y Robert Cowen (Eds.). *PISA Under Examination: Changing Knowledge, Changing Tests, and Changing Schools.* Sense Publishers. Rotterdam.

Salinas, F. J. and Santín, D. (2011). Are you on the educational production frontier? Some economic insights on efficiency from PISA. pp. 169-182. In Pereyra, M.A., Hans-Georg Kotthoff y Robert Cowen (Eds.). *PISA Under Examination: Changing Knowledge, Changing Tests, and Changing Schools*. Sense Publishers. Rotterdam.

Samuel Bowles, S. Towards an educational production function, in W. Lee Hansen (ed.), *Education, Income, and Human Capital*, NBER, pp. 9 - 70

Santin D. y Sicilia, G. (2014) *"¡Quiero cambiar a mi hijo de grupo! Factores explicativos de la eficiencia técnica de los colegios en España,* Revista de Evaluación de Programas y Políticas Públicas, Núm. 2 (2014), pp.79-109

Schütz, G., M. R. West and L. Wöbmann (2007), "*School Accountability, Autonomy, Choice, and the Equity of Student Achievement: International Evidence from PISA 2003"*, OECD Education Working Papers, No. 14, OECD Publishing. http://dx.doi.org/10.1787/246374511832

Schütz, G., M.R. West and L. Woessmann (2007): *School Accountability, Autonomy, Choice, and the Equity of Student Achievement: International Evidence from PISA 2003*, OECD Education Working Papers, No. 14, OECD Publishing.

Simar, L. and Wilson, P. (2000). *A general methodology for bootstrapping in non parametric frontier models*, Journal of Applied Statistics, 27(6): 779-802

Simar, L. and Wilson, P. (2001). Aplicación del bootstrap para estimadores D.E.A. In: Avarez Pinilla, A. (Ed.), *La Medición de la Eficiencia y la Productividad*. Pirámide, Madrid.

Simar, L. and Wilson, P. (2004). Performance of the bootstrap for DEA estimators and iterating the principle. In: Cooper, W.W., Seiford, L.M., Zhu, J. (Eds.), *Handbook on Data Envelopment Analysis*. Kluwer Academic Publishers, Boston, pp. 265–298.

Simar, L. and Wilson, P. (2007). *Estimation and inference in two-stage, semi-parametric models of production processes*, Journal of Econometrics, 136: pp. 31-64

Simar, L. and Wilson, P. (2011) *Two-Stage DEA: Caveat Emptor*, in Journal of Productivity Analysis (2011) 36:205–218

Sliwka, A. and Istance, D. (2006) Choice, Diversity and "Exit" in Schooling – A Mixed Picture, European Journal of Education, Vol. 41, No.1

Söderström, M. and R. Uusitalo (2005), *"School choice and segregation: evidence from an admission reform,"* Working Paper Series, IFAU - Institute for Labour Market Policy Evaluation.

Thanassoulis, E. (2001) Introduction to the theory of and application of DEA, Kluwer Academic Publisher.

Todd, Petra E., and Kenneth I. Wolpin. 2003. "*On the Specification and Estimation of the Production Function for Cognitive Achievement*." The Economic Journal, 113 (February), F3–F33.

Vandenbergue, V (1999) *"Economics of Education. The need to go beyond human capital theory and production-function analysis"*, Educational Studies, Vol. 25 (2), 129-143.

Warm, T. A. (1989). *Weighted likelihood estimation of ability in the item response theory*. Psychometrika, 54, 427-450.

Waslander, S., C. Pater and M. van der Weide (2010), *"Markets in Education: An Analytical Review of Empirical Research on Market Mechanisms in Education"*, OECD Education Working Papers, No. 52, OECD Publishing.

Willms, J. and F. Echols (1993) The Scottish Experience of Parental School Choice, in Rasell E. and R. Rothstein (Eds), *School Choice: Examining the Evidence*, Economic Policy Institute, Washington DC.

Woessmann, Lüdeman, Schütz and West (2007), "*School Accountability, Autonomy, Choice, and the Level of Student Achievement: International Evidence from PISA 2003*", OECD Education Working Papers, No. 13, OECD Publishing.

Xue, M. and Harker, P.T. (1999) *Overcoming the Inherent Dependency of DEA Efficiency Scores: A Bootstrap Approach*, Working Paper, Wharton Financial Institutions Center, University of Pennsylvania.