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IS PRIVATE EDUCATION BETTER? EVIDENCE FROM CHILE

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Resumen

Este artículo usa el sistema de vouchers chilenos para proveer nueva evidencia respecto de si los colegios privados son más eficientes que los colegios públicos. Contribuye a estudios previos chilenos al reducir el sesgo de selección e introducir efectos heterogéneos. Los resultados sugieren que los colegios públicos no son ni uniformemente peor ni mejor que los privados. Más aun, los colegios públicos son relativamente más efectivos para alumnos de familias de estratos socio-económicos más bajos. Este sistema de ventajas comparativas es consistente con la coexistencia de colegios públicos y privados en la mayoría de la comunas Chilenas.

Abstract

This paper uses Chile's voucher system to provide new evidence on whether private schools are more efficient than publicly operated schools. It contributes to the world debate by analyzing a universal voucher system. It contributes to previous Chilean studies by reducing the selection bias and allowing heterogeneous treatment effects. The results suggest that public schools are neither uniformly worse nor better than private schools. Rather, public schools are relatively more effective for students from disadvantaged family backgrounds. Such a system of comparative advantage is consistent with the coexistence of public and private schools in most Chilean communes.

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Introduction

One of the most important questions confronting education policy makers is whether the efficiency of the education system could be improved by introducing some degree of competition into the supply of education services. Friedman (1955) argued that private schools are inherently more efficient than publicly operated schools, and advocated a competitive system of publicly-funded student vouchers in which parents have free choice among schools. Recently, the voucher idea has gained increasing credence in the United States. Several cities, including Milwaukee, have introduced freedom of choice for certain students at the taxpayers' expense (Rouse (1998), Greene, J. P., Peterson, P. E., & Du, J. (1998), Hoxby (2001)). Similarly, the State of Florida has introduced a plan that provides vouchers to students in low-performing school districts (Figlio and Rouse, 2000). Charter schools in Michigan and Arizona also seak to increase freedom of choice and capture the expected benefits of such reforms (Hoxby, 2002). Nevertheless, vouchers and choice reforms are still controversial, and as yet no state or district has made them available to all students.

In 1981, Chile introduced a massive reform to its education system that included a voucher program similar in spirit to Friedman's "ideal" system. In particular, under the Chilean system parents can send their children to public schools, or to private schools that agree to take a voucher as full payment for the cost of education[1]. Private schools have flourished under the Chilean voucher system, and now account for 36% of elementary enrollment in the country.

[1] Starting on 1996, private subsidized schools were allowed to charge for tuition. The value of the voucher they received was reduced to account for the increase in resources received through tuition.

In this paper, I use the unique experiences of Chile to provide new evidence on the central question of whether private schools are indeed more efficient[2] than publicly operated schools. Several features of the Chilean system make this a particularly useful exercise. First, relatively high quality data are available on student and school characteristics, and on school-wide average standardized national test scores. Second, unlike the limited voucher programs in the U.S., vouchers in Chile are available to all families, and are indeed used by a wide range of families.

The results of my analysis suggest that public schools are neither uniformly worse nor uniformly better than private schools. Rather, public schools appear to be relatively more effective for students from disadvantaged family backgrounds. Such a system of comparative advantage is consistent with the observation that public and private schools continue to co-exist in most Chilean communes. Moreover, it is consistent with other features of the Chilean data, including the under-representation of disadvantaged students in the private schools (despite the fact that these schools are free), and in larger class sizes in private versus public schools.

[2] Throughout the text the word efficient is used to refer to the school with higher scores. The assumption is that all resources, or most of them, are those linked with the fixed per student subsidy and therefore one could think that they achieve more "output" at the same "cost".

2. Education System in Chile

In 1981 the Chilean military government implemented a voucher-style system of publicly funded education (i.e. fixed per pupil subvention) that transfers funds from the central government to both public and private schools on an equal basis[34]. In order to be eligible to receive voucher payments, subsidized schools must meet certain minimal safety, attendance, infrastructure, and curriculum requirements. Until 1996 they were not allowed to charge tuition. The per pupil voucher is paid on a monthly basis by the central government directly to the school in the case of private subsidized schools and to the municipality in the case of public schools[5]. The per student stipend is independent of the public or private status of the schools, but varies somewhat across regions, this variation is geared towards benefiting otherwise disadvantaged areas of the country.

Overall demand-side selection in the Chilean voucher system is lower than any of the experiences observed abroad. Public and private subsidized schools compete for the same kind of students, those that can't or don't pay the private tuition costs, reducing demand side selection. Furthermore, there is no restriction on the location of the school the child can attend. Except for the time constraint and safety issues, children can travel free of charge to any part of town to attend the school of their choice[6].

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[3] For a detailed description of the Chilean education system and its reform see Gauri (1998), Tessada (2000), Cox (1997) or Bravo, Contreras, and Sanhueza (1999).

[4] It is quite important to mention that the political scenario in which this national policy was implemented was fundamental in making it possible. Trying to replicate the same policy under alternative political conditions than those that existed in Chile during the early 1980's may require more convincing empirical evidence.

[5] This is different from the traditional voucher given to the student. Benefits of student based voucher: student families really understand that they can hold schools accountable and exert their "voice and exit" behaviour to increase their children's education. Additionally, it allows differentiating between students needs. The benefits of school based vouchers is that lower administrative costs and the possibility of making the benefit a function of school characteristics.

[6] This freedom of choice between schools is less for younger children since it is probable that their families

On the supply side, slots at public school are rationed on a *first come first serve* basis. Public schools cannot select students using tests or interviews, unless there is excess demand[7]. The same is not true for private subsidized schools, that tend to select students according to family characteristics and previous performance. This introduces potential selection bias that has to be incorporated in the model and interpretation of the results.

The expected benefits of introducing this pro-choice reform are two-fold. Initially, it increases the supply of private subsidize schools, which are assumed (by many) to be more efficient in providing education services give their structure and profit miximixing objective. Secondly, and most importantly it introduces competition between schools which should induce an overall increase in the *quality* of education as schools "fight" to attract and keep the best students.

In the Chilean context, the first effect of the free-choice reform was observed intantaneously as te number of private subsidized schools flourished in the early 80's. The second effect is less clear, atleast for the public schools whose internal organization reduces the potential benefits of the voucher program from induced competition. Public schools depend on the municipal government and the voucher is paid to the municipality, not to the school. The municipality then allocates school expenditures between all the schools that depend on them. Principals can influence expenditure decisions by lobbying, but they don't have a formal right over the funds. Profits or losses are returned to the municipality and are distributed between the schools. Therefore, school personnel do not reap the benefits or

will not want them to travel around the city alone and going with them is costly.

[7] The best public schools that have excess demand do select students on the basis of their "quality".

costs of inefficient education provision. In general, schools are not perceived badly if they have deficits and principals are not held accountable for the education outcomes.

Additionally, “cream-skimming” by private schools affects the public schools performance in several ways. First, it drains the public schools of the best students, immediately affecting test scores negatively. Additionally, the group of students that stays in the public schools may perform worse because of negative peer effects. Second, the incentives faced by public schools to increase quality may be reduced since the remaining students are "locked in" and cannot exercise the exit option that would drive competition-induced improvements.

Even if such “cream skimming” effect is not as big to overcome the competition effect it is not clear that schools would actually compete on the basis of *quality*. In theory, families choose schools on the basis of quality normally measured by student performance in national standardized tests or labor markets. The availability and reliability of either measure of quality is not good given the lack and lag[8] of such information and families are left choosing on the basis of names, infraestructure and “gutt” instinct, therefore reducing the real pressure of competition to compete on the basis of quality.

3. Key Issues

3.1. School selection or non-random assignment of students

Assessing the achievement differential between school types requires comparing the outcome variable $T_{i,PS}$ and $T_{i.PU}$ (i.e. test score, future wage, entry to college rate, etc.) of the

[8] In Chile the test scores were kept confidential in the 80’s and when they became public they were not easily available to the families. Public measures of labor market performance by school are inexistent.

same student i in both types of schools (private subsidized (PS) and public (PU)). To infer causality, assignment into schools must be random. In such cases (i.e. in actual randomized experiments), the treatment effect on the treated is given by the difference in the average outcomes between public and private schools:

Treatment on the treated: $\tau|_{PS=1}=E(T_{i,PS}|PS=1)-E(T_{i,PU}|PS=1)$

Treatment on the not treated: $\tau|_{PS=0}=E(T_{i,PS}|PS=0)-E(T_{i,PU}|PS=0)$

With non-experimental data the treatment effect is not observable. We do not observe the outcome variable of the treatment group if not treated $E(T_{i,PU}|PS=1)$ or of the control group if treated $E(T_{i,PS}|PS=0)$ (i.e. the outcome of private (public) school students if they went to public (private) schools). This is so because students will sort and be selected into schools according to unobservable characteristics that are correlated with performance and thus will not be comparable.

Student selection or non random assignment may result from several processes. In the first place, self selection or sorting of students into schools may arise from the discretion granted to families to choose schools and the way in which they make their choices. Family and school characteristics may be systematically related, resulting in a segmented educational system in which students from similar backgrounds will attend the same schools and hardly ever have contact with students from other realities. For instance, less educated families may invest less in the school choice decision and hence, be less informed than families that place greater value on educating their children. Alternatively, the screening of students through family interview, previous achievement, etc., will result in nonrandom selection. Schools affected by the competition induced by the voucher system (i.e. mostly private schools, because of their organizational structure), will accept and attract students that raise the perceived quality of the school (i.e. by increasing the test score and presence in higher achievement-SES segment of the population), which attracts more and better students. Additionally, the relative institutional uniqueness of private schools may also be an artifact of the student population. Schools develop reputations in communities: “Better schools will attract better students and teachers”. The quality of the students, in terms of both achievement and behavior, may allow for greater administrative restraint, more teacher autonomy, and greater satisfaction among personel. And further, all these factors may not only affect, but also be affected by student achievement in a reciprocal causal process. Another source of selection comes from only considering students that have kept up with their grade. In other words, those that flunk are not observed and therefore not included in the estimation.

With non-experimental data, estimated treatment effects may be biased due to omitted relevant variables that are correlated both with the type of school they assist and their performance at any school. In terms of the notation introduced above, non-random assignment will indicate that the term in parenthesis is non-zero:

$$\tau_o=E(T_{i,PS}|PS=1)-E(T_{i,PU}|PS=0)= \tau|_{PS=1}+[E(T_{i,PU}|PS=1)-E(T_{i,PU}|PS=0)]$$

If selection is on unobservables, this bias cannot be eliminated through regression adjusting. This occurs when we do not observe the variables that determine assignment and when such variables are related with the outcome variable (such as IQ that influences the school decision and also the expected outcome). In this case, techniques such as IV estimates and first stage selection models included in second stage outcome estimates are used to obtain bias free estimates. But finding good instruments is not a trivial task.

Fortunately, identification is possible if we assume selection on observables. In this case, the assignment mechanism conditional on the observable variables (X) is comparable to a randomized experiment (Rubin 1977). The bracket term in the above equation is still not zero because assignment is non-random but we observe the variables that determine selection and therefore can obtain ignorable treatment assignment. Hence,

$\tau|_{PS=1}=E(T_{i,PS}|PS=1)-E(T_{i,PU}|PS=1)=E_x\{E(T_i|X_i,PS=1)-E(T_i|X_i,PS=0)|PS_i=1\}$

$\tau|_{PS=0}=E(T_{i,PS}|PS=0)-E(T_{i,PU}|PS=0)=E_x\{E(T_i|X_i,PS=1)-E(T_i|X_i,PS=0)|PS_i=0\}$,

where $T_i=PS_i*T_{i,PS+}$ $(1-PS_i)*T_{i,PU.}$

The assumption made is that since treatment is dependent on observables, one can take assignment to treatment conditional on X as a random variable, just like in an experiment. Therefore, comparing the outcomes for two schools with identical observable characteristics, one of which is private subsidized and the other public, is like comparing those two schools in a randomized experiment. This is what most of the previous studies have done. They have included an extensive list of variables in the outcome equation trying to control for all sources of selection bias that results from observable characteristics.

As with other studies, accounting for selection bias will be an important task of this paper. However, as was explained earlier, thanks to the design of the voucher system in Chile, it is lessened. In addition, I make use of an unusually large set of controls taken from the merge of the school data sets with household surveys to further control for. This individual-level socioeconomic data allows the modeling of selection explicitly, and its introduction in a second stage equation of test scores. Finally, models controlling for unobserved selection assuming joint normality of the error terms are run using one and two latent factor models a la Heckman.

Unfortunately, student level data of the outcome variable is not available, and therefore the analysis will be limited to school averages. This implies that the within-school variation cannot be used.

3.2. Standardized Test Scores as the Outcome Measure

Another key element to consider is the selection of a measure for the relative effectiveness of schools. What is it that we want from schools? Better standardized test scores, better wages, better social skills, lower criminality, etc… Even though all these are desirable outputs, this paper will use standardized test scores as a partial measure of quality. Test scores have the advantage of allowing objective comparisons. The use of 4th grade test scores limits the amount of other factors that might be playing a role in explaining the outcome. That is, since education is cumulative, test scores for higher grades or even university degrees or PAA[9] scores, would require controls for switching between schools and other external factors which might influence the result. Similarly, when using wages, there might be factors, such as luck and personal contacts, involved in the outcome that we can't control for. Furthermore, there are studies that show that achievement test scores are positively correlated with future labor market outcomes.

[9] PAA is equivalent to SAT in US.

All the analisis presented in the paper considers math test scores as the endogenous variable. Results using language scores are not too different and therefore are omitted. Furthermore, math scores are used because past research has shown that they are more related to school characteristics and future earnings (Murnane et al. 1985, Madaus et al. 1979 and Barro 2001).

On the down side, there is some evidence that test scores are a short-term measure of school effectiveness. For example, teachers may train students to perform well on a particular type of test, without any long-term effects on human capital accumulation. (They even may select the better students to take the test, or give out the answers). Also, availability of better teachers and more school resources may not have an impact on the test scores in the short run, but may have an influence in the long run.

4. Estimation Strategy

A school can be thought of as a firm that is producing an output (in our case, test score (T)), with a set of observed (X) and unobserved inputs (μ). The production function for both types of schools can be expressed as:

(1) $$T_{PS,i,j} = a_{PS} + X'_{i,j} b_{PS} + m_{PS,i,j}$$

(2) $$T_{PU,i,j} = a_{PU} + X'_{i,j} b_{PU} + m_{PU,i,j}$$

Where: PS=Private School, PU= Public School, i=1-N schools and j=1-J students.

Selection can be modeled by assuming that the attendance to PS school, or treatment, is a linear function of observable characteristics W and an error (ν).

(3) $$PS_{i,j} = 1[W'_{i,j}\,\Pi + n_{i,j} > 0]$$

Since I do not have student level data, estimates are based on school-based aggregations. Mean test score is the dependent variable and mean school, teacher, and student characteristics are the independent variables. In terms of equation (1)-(3) we will be estimating the following:

(1') $$\overline{T}_{PS,i} = a_{PS} + \overline{X}_i' b_{PS} + m_{PS,i}$$

(2') $$\overline{T}_{PU,i} = a_{PU} + \overline{X}_i' b_{PU} + m_{PU,i,j}$$

(3') $$\overline{PS}_i = 1[\overline{W}_i'\Pi + n_i > 0]$$

Where the overbars represent school means. For ease of notation, the overbars will be ommited in the rest of the paper. All variables with sub index i and no j are school means.

4.1. Case I: Random Treatment Assignment or No Selection Bias

The first set of models estimate the treatment effect by assuming that assignment to treatment is random or not correlated with the outcome variable (i.e. test scores). For such purpose we assume that μ_i and ν_i are iid and $E(\mu_i|X_i,\nu_i) = E(\mu_i|X_i) = 0$. In this case, the population regression function and the regression functions for the observed subsamples are identical.

(4) $$E[T_{PS,i} \mid X_i, PS_i = 1] = E[T_{PS,i} \mid X_i] = a_{PS} + X_i' b_{PS}$$

(5) $$E\left[T_{PU,i} \mid X_i, PS_i = 0\right] = E\left[T_{PU,i} \mid X_i\right] = a_{PU} + X_i' b_{PU}$$

Therefore, the treatment effect or relative efficiency differential can be simply calculated as the difference between the mean test scores conditional on the observable characteristics in private and public schools. In this case, the estimation of equation (6) by OLS leads to an unbiased estimate of the treatment effect.

(6) $$E\left[T_{PS} \mid X_i\right] - E\left[T_{PU} \mid X_i\right] = a_{PS} - a_{PU} + X_i'\left(b_{PS} - b_{PU}\right)$$

Equation (6) estimates the impact on the test score of being in a private school, with respect to a public school, controlling for observed family, student and school characteristics. In theory, the coefficient measures what happens to the test score if we take a public school, with its students, teachers and families intact, and transform it into a private school by changing its administration, but not its resources. Alternatively stated, the coefficient provides the test score difference between two identical schools, except for the fact that one is private and the other public[10].

Previous studies for Chile have estimated an additive constant treatment effect, which in terms of equation (6) implies that they are restricting the β's of both types of schools to be equal but allowing the α's to vary. In other words, they are assuming that the production functions are parallel and that their difference between the test scores (treatment effect) is constant and equal to the difference between the α's.

Most of these constant treatment effect estimates for Chile conclude that private subsidized schools generate either higher test scores or not significantly different from

[10] It must be noted that this methodology may be flawed by the fact the resources are endogenous to school

those from public schools. For example, Rodriguez (1988), using a sample of 281 schools in the metropolitan area concludes that private schools outperform public ones in the 1984 PER exam. Aedo and Larrañaga (1994), using data on 1990-91 and Mizala et. al. (1997 and 2000), using data for 1994-95 and 1996 find positive or no difference in test scores between school types. Bravo, Contreras and Sanhueza (1999) use data from 1982 onwards to run a series of cross sectional regressions similar to equation (6), finding that the performance gap favorable to private schools is positive for the earlier years but decreases and turns insignificant for the later ones. Winkler and Rounds (1993) analyze school expenditures and conclude that private schools are more efficient. However, Parry (1996) finds no significant difference between the achievement of both types of schools. Schiefelbein (1991) and Rodriguez (1988) found that non-profit private subsidized schools provide higher quality education than profit maximizing private subsidized schools.

In terms of the model that is being estimated it corresponds to some version of equation (7), where the treatment effect is $\gamma=\alpha_{PS}-\alpha_{PU}$ and corresponds to the absolute advantage model in which private schools are assumed to be more efficient for all types of students.

(7) $$T_i = \alpha_{PU} + PS_i\gamma + X_i'\beta + \mu_i$$

However, linearity and additivity of the treatment effect are not necessary assumptions. A more realistic scenario is to assume that the achievement differential varies with observable characteristics. If the organizational differences of private subsidized schools make them more prone to competition and more adjustable to students needs, and

type (see Filmer and Prittchet, 1999).

thus more efficient than public schools, one might expect that their advantage will be higher the more resources they have to adjust to changing needs. This is so because if they are resource constrained they will be less likely to adjust and therefore be much more like public schools. Another possibility is that since private schools will select the "better"[11] students, they will be likely to direct their efforts and resources towards meeting the needs of these "better" students and not those of the "worst" ones. Therefore, one might expect that the benefits for students from less advantaged backgrounds of attending a private school are relatively lower conditional on being admitted.

To capture the possibility of differential effects by school-teacher-family characteristics under the selection on observables assumption, I estimate equation (8). The inclusion of interaction terms is an innovation to previous literature that increases flexibility in the estimation and allows for heterogeneous treatment effects. The treatment effect is equal to $\gamma + X'_i\delta = \alpha_{PS}-\alpha_{PU} + X'_i(\beta_{PS}-\beta_{PU})$.

(8) $$T_i = \alpha_{PU} + X_i'\beta_{PU} + PS_i\gamma + PS_i X_i'\delta + \mu_i$$

Equation (8) allows for the estimation of the distribution of the effect, which is not possible for in previous estimates of production functions similar to equation (7). It is my opinion that if treatment is in fact heterogeneous one must not only observe averages but also the distribution of the effects. If one believes that the winners from these types of school choice policies are students from less advantaged areas, as school choice proponents do, then one should look specifically at the effects on those students, which might be

[11] Better refers to students coming from families with higher education and income.

different from that of students from less disadvantaged backgrounds. This is what equation 8 is capturing.

4.2. Case II: Non Random Treatment Assignment

The last set of estimations consider the possibility of non-random assignment by assuming that $F(\mu_{PS}, \mu_{PU}, \nu)$ is a trivariate normal distribution. In this case assignment and test scores are no longer independent and therefore the population regressions differs from the observed samples regressions by $E[\mu_{PS,i}|X_i,\nu_i]$ and $E[\mu_{PU,i}|X_i,\nu_i]$. But by using the properties of the normal distribution that term can be calculated and included in the regression:

(9) $$E[T_i \mid X_i, PS_i = 1] = \alpha_{PS} + X_i'\beta_{PS} + E[\mu_{PS,i} \mid X_i, \nu_i]$$

(10) $$E[T_i \mid X_i, PS_i = 1] = \alpha_{PS} + X_i'\beta_{PS} + E[\mu_{PS,i} \mid X_i, \nu_i > -W_i'\Pi]$$

(11) $$E[T_i \mid X_i, PS_i = 1] = \alpha_{PS} + X_i'\beta_{PS} + \frac{\sigma_{\mu_{PS}\nu}}{\sigma_\nu^2} \lambda_{PS}(W_i'\Pi)$$

Analogously for public schools:

(12) $$E[T_i \mid X_i, PS_i = 0] = \alpha_{PU} + X_i'\beta_{PU} + E[\mu_{PU,i} \mid X_i, \nu_i < -W'\Pi]$$

(13) $$E[T_i \mid X_i, PS_i = 0] = \alpha_{PU} + X_i'\beta_{PU} + \frac{\sigma_{\mu_{PU}\nu}}{\sigma_\nu^2} \lambda_{PU}(W_i'\Pi)$$

Where,

$$(14) \qquad \begin{aligned} l_{PS} &= \frac{f(W_i'\Pi)}{\Phi(W_i'\Pi)} \\ l_{PU} &= -\frac{f(W_i'\Pi)}{1-\Phi(W_i'\Pi)} \end{aligned}$$

Following Heckman (1979) the λ's are computed by running a first stage probit model of P(X) as a function of individual SES variables (W_i) and using the estimated coefficients in the λ's formulas. The treatment effect can then be computed as the difference between (12) and (13). The estimated treatment effect will differ from the one estimated by OLS because it will include an additional term that controls for the selection bias ($\rho_{\mu,PS,\nu}\lambda_{PS}$ - $\rho_{\mu,PU,\nu}\lambda_{PU}$).

4.2.1. 1-Factor Model of Latent Test Scores or Absolute Advantage

One common assumption made in these models is that the correlation between test score and assignment (ρ's) of both types of schools is the same. In this case, following the absolute advantage story, students selecting one kind of school (i.e. private) would outperform the other students in any type of school. That is, if there is positive selection into private schools ($\rho(\mu_{ps},\nu)>0$) there must be negative selection into public schools ($\rho(\mu_{pu},\nu)>0$). Thus, the expected test score for the subsample of students that go to private schools exceeds the population expectations ($E(T_i/X_i, PS=1)>E(T_i/X_i)$) and the opposite is true for public school students ($E(T_i/X_i, PS=0)<E(T_i/X_i)$), implying that the treatment effect estimates that ignore the selection bias are upward biased.

To be consistent with the above estimates, we estimate the constant and heterogeneous treatment effects with equal ρ's from equations (15) and (16).

$$(15)\qquad \begin{aligned} E[T_i \mid X_i, PS=1] - E[T_i \mid X_i, PS=0] &= \alpha_{PS} - \alpha_{PU} + \rho\left(\lambda_{PS} - \lambda_{PU}\right) \\ E[T_i \mid X_i, PS=1] - E[T_i \mid X_i, PS=0] &= \gamma + \rho \frac{\phi}{\Phi(1-\Phi)} \end{aligned}$$

$$(16)\qquad E[T_i \mid X_i, PS=1] - E[T_i \mid X_i, PS=0] = \gamma + X_i'\delta + \rho \frac{\phi}{\Phi(1-\Phi)}$$

4.2.2. 2-Factor Model of Latent Test Scores or Comparative Advantage

In contrast to the absolute advantage story, students may select the schools that benefit them the most and therefore there could be positive selection into both types of schools. To allow for this we let $\rho(\mu_{ps},\nu)$ to differ from $\rho(\mu_{pu},\nu)$. In the case of positive selection into PS and PU ($\rho(\mu_{ps},\nu)>0$ and $\rho(\mu_{pu},\nu)<0$)) we would have $E(T_i/X_i, PS=1)>E(T_i/X_i)$ and $E(T_i/X_i, PS=0)>E(T_i/X_i)$, and the impact on the treatment effect will be ambiguous.

The models estimated in this case correspond to equations (17) and (18).

$$(17)\qquad E[T_i \mid X_i, PS=1] - E[T_i \mid X_i, PS=0] = \gamma + \rho_{\mu_{PS},\nu} \frac{\phi}{\Phi} + \rho_{\mu_{PU},\nu} \frac{\phi}{1-\Phi}$$

$$(18)\qquad E[T_i \mid X_i, PS_i=1] - E[T_i \mid X_i, PS_i=0] = \gamma + X_i'\delta + \rho_{\mu_{PS},\nu} \frac{\phi}{\Phi} + \rho_{\mu_{PU},\nu} \frac{\phi}{1-\Phi}$$

5. The Data

The data used come from the Ministry of Education and the Socioeconomic Household survey. The school level data sets of the Ministry provide outcome variables (i.e. test scores) as well as school and teacher characteristics. Student characteristics are obtained from the Household Socio-Economic Surveys (CASEN). The data sets are merged together by using the school id number. Only elementary schools are included in the analysis in order to limit the uncontrolled switching between schools and the cumulative aspect of education. Below is an outline of the data sets and variables.

Data Sets:

Ministry of Education Data Sets: All data is school level, no individual observations on students

1. Simce Enrollment directory
2. Teachers Directory
3. Socioeconomic Vulnerability Index JUNAEB

Variables:
School Characteristics

1. 4^{th} Grade average math and Spanish test scores
2. Administrative Dependence: Municipal, Private Subsided, Private
3. Enrollment (total, per grade, male, female)
4. Number of students per class (per grade/total)
5. Number of teachers per school
6. Percentage of titled teachers
7. Number of years teaching
8. Number of hours per teacher (real and contract)
9. Percentage of male teachers

Socioeconomic Characteristics of Students

1. Vulnerability Index: Function of mother education and a group of health indicators for the child (dental cavities, malnutrition, hearing problems, eye problems and posture problems).

CASEN (Socioeconomic characteristic household survey) **Variables:**

1. Household size (number of people in family)
2. Poverty line (rank 1-3 with respect to poverty line)
3. Total household income
2. Father's Education (years, degrees)
3. Mother's Education (years, degrees)
4. Students age, grade and sex

The focus of this paper will be on the 1996 cross section of schools. Unfortunately, since the data do not cover the period before the vouchers were implemented there is no good reason to use the data in a time series way.

When using the Ministry of Education data sets we are able to identify 5630 schools whose dependency composition mimics that of the universe of schools, that is 61.5% correspond to public, 29% to private subsidized and 9.5% to paid private schools. Unfortunately the information available on family background is very scarce[12]. In an attempt to make results less susceptible to selection bias we averaged family characteristics from the household survey data at the school level[13]. (To increase precision both surveys for 1996 and 1998 were merged to calculate the average family characteristics assuming that there is not much change between those years). The surveys do not allow us to match all schools contained in the ministry of education data, further restricting our sample to 3500 to 4000 schools, of which 57% are public schools, 34% private subsidized schools and 9.1% private paid schools. When testing for non-random exclusion of schools we find no statistical significant difference between the coefficients of the restricted and unrestricted samples.

Table 1 presents the sample means of the school, teacher and student characteristics of the three types of schools. Private subsidized schools don't appear to have better learning conditions than public schools. They tend to be larger (in terms of enrollment) and with larger classes (calculated as the number of students enrolled per grade divided by the amount of classes in each grade). One could argue that these conditions are detrimental to education if personalized teaching is beneficial. Of course, economies of scale, compensatory classes and measurement errors point in the opposite direction.

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[12] The only SES information available from the ministry is the vulnerability index, parental education index, and average family spending in schooling index.

[13] Most of the other studies done with chilean data restrict the variables to those available from the ministry. The rest, rely on in-school surveys to include additional variables on student-family-school characteristics. Unfortunately, these surveys are non universal and the samples get restricted substantially.

Percentage of male teachers, years of experience, hours worked/contractual hours and percentage of teachers measure teacher characteristics in this data with a degree in education[14]. Again, private subsidized schools don't have "better" teachers: They have relatively fewer teachers with a degree in education and teachers with less years of experience, working on average fewer hours. They also have a higher percentage of female teachers.

Selection based on observables is still present and evident from the means presented in family background characteristics in table 1. Private subsidized and public schools tend to attract student from a lower socioeconomic status than private schools (as measured by higher parental income and education, lower vulnerability index), and between private subsidized and public schools there is still some sorting going on. Children from relatively better family backgrounds appear to be attracted or captured by private subsidized schools.

The observed differences in resources and student characteristics plague direct outcome comparisons with selection bias. The 5-6 percentage point difference in private subsidized and public schools' average test scores could very possibly just be the effect of non-random assignment of students into schools (i.e. of having better students and not really teaching them better).

Graph 1 shows the distribution for 4th grade math scores in 1996 by school type. It is evident from the graph that the public schools concentrate in lower achieving portions of the distribution, while private paid schools do so in higher achieving portions. Private

[14] This measure is not so indicative of the teaher's quality, some measure of wages would also be desirable but is unavailable. With respect to teachers with university degrees, the data allows for controlling what type of degree they have (i.e. education, physics, etc) and even though one could think that having a degree in some other area (not education) may be more beneficial to teaching than having an education degree, I believe

subsidized schools lie in the middle. In terms of standard deviation of the test scores, private paid schools have the lowest inter school variance, followed by public schools and private subsidized schools, respectively. When testing for equal distributions, we cannot reject equality between public and private subsidized schools score distributions at a 95% confidence. The private paid score distribution is significantly different from both private subsidized and public score distributions. This simple test corroborates the previous statements assuming less dispersion within PS and PU schools, than with private paid schools. Together with the following description on the school-family-teacher characteristics, it helps explains why the working sample will be limited to PS and PU schools only. Private paid schools are excluded from the analysis because of its inherently different distribution of family as well as school characteristics that make comparisons misleading.

Table 2 computes the relative performance within sub-samples as a first approach to reducing the bias in the computed differentials. The first thing worth noticing is that there are several large and negative relative difference indicators for private subsidized schools (with respect to public schools). When stratifying the sample by socio-economic status, as measured by average parental education, maternal education or vulnerability index, one observes that public schools cater to low SES families, private subsidized schools do so for intermediate SES families, and paid private schools do so for high SES families. As expected, test scores increase as the average SES variable increase. Within those categories, private subsidized school's relative advantage over public schools remains only for higher SES groups, but reverses for lower SES groups.

that this is true for older children and therefore just include the degree in education information.

Private schools tend to concentrate in urban areas (50% of the schools in the urban area are private subsidized and paid). 81% of the rural schools are public. The relative advantage of private schools over public schools remains only in urban areas. In rural areas, public schools have on average 2-3% score advantage over private subsidized schools[15]. One possible explanation is that in rural areas the selection of students is lessened, as well as the average SES of the student's families, and therefore private subsidized schools no longer have better students to educate.

With respect to class size (both total and 4th grade) public schools have an advantage over private subsidized schools in smaller classes, but not in bigger classes. Not surprisingly, they normally have smaller class sizes.

Graphs 2 through 5 show the trend lines from scatter plots for average school 4th grade math score by log of household income, log of parental income, maternal education and vulnerability index. Consistently it is found that for any one of this measures of parental background, private subsidized schools perform better than public schools only when the students come from a less disadvantaged background (i.e. higher maternal income, higher log household income, etc). That is, if we choose to compare the average test score for schools with students that come from the less advantaged families, we would find that public school's achievement is higher, and the opposite is true for students coming from higher socioeconomic status. These findings are consistent with the comparative advantage theory. It is not that private schools have an absolute advantage on producing

[15] This observation is of great importance and stands as a future extension to the analysis in this working paper.

higher test scores; they only have a comparative advantage in teaching children that come from better socioeconomic background.

Given the characteristics of the students attending each type of school, it appears that the different types of schools specialize in a manner best suited to the educational needs of their respective student bodies. That is, private subsidized schools attract higher income/parental education students and public schools attracts lower income/parental education students because they can perform relatively better than the other type of school with students with similar socioeconomic characteristics.

6. Estimation of the Treatment Effect

6.1. Case I: Random Assignment

This section estimates the models presented in section 5. I allow the effect of private schools on test score to vary by the observable characteristics of schools, families, and students. The production functions present the predicted test scores at each set of teacher-family-school characteristics and the difference between them is the test score gain (or loss) of private subsidized schools over public schools at each of this sets of characteristics (i.e. the treatment effect). Since the treatment effect is likely to be heterogeneous, it is better to present the distribution of the effects and not just the average effect or the treatment on the treated or not treated effect. Estimations based on equation (8) that allow for heterogeneous treatment effects (i.e. different slope and intercepts) allow the identification of the distribution of the effects, which is a more complete and relevant result.

To maintain consistency and comparability with previous research, models like the one in equation (7) are also estimated. The inclusion of models based on equation (8) is an innovation to earlier research and is presented after the traditional estimations.

Table 3 presents the estimated "intercept effect" as controls and interaction terms are sequentially added in the model. The effect presented in the first three rows is theoretically equivalent to the average treatment effect estimated in previous studies (except for the differences in samples and controls used), since it estimates equation (7) without allowing for heterogeneous effects by not including interaction terms. The results are consistent with previous studies: As we move towards more inclusive models we find that the magnitude of the treatment effect (i.e. the gain of private subsidized schools over public schools in test scores) diminishes from 4.07 to -0.14 points. This diminution reflects the selection effect mentioned above, that is, private subsidized schools select and attract "better students", therefore the uncontrolled effect is upward biased. It is also worth mentioning that when the school controls are included with no SES controls the effect is bigger since, as shown in table 1, the school characteristics of private subsidized are not better than that of public schools.

It is interesting to observe that the effects are different according to the samples analyzed. When urban and rural schools are merged, the effect after controlling for SES and schoool characteritics turns to zero, but in the urban sample, even though the effect gets smaller, it is still positive. The rural sample is quite different. As was seen in the raw data (and consistently with what Mizala and Romaguera (2000) found), the differences in performance between the schools is not significant even when the controls are added in.

The fourth row of table 3 allows for heterogeneous treatment effects by including interaction terms in the analysis. The model estimated corresponds to equation (8). The interaction terms correspond to the multiplication of the private subsidized dummy and some SES and school variables. Now, the coefficient for PS is no longer the average treatment effect. It can be interpreted as the effect of being a private subsidized school at the y axis or X equal 0. In all samples this effect is largely negative. Thus indicating that the only way we can have an average treatment effect that is positive or null is that there must be some positive effects along the X axis, implying the existence of heterogeneous effects.

If we are socially motivated, what we are really interested in is the effect of the policy in those kids that are in most need of better education[16]. This motivates the introduction of the heterogeneous treatment effect models to capture the differential effects along the X-axis, and to be able to observe the predicted distribution of such effects.

Model IV in Table 4 presents the estimated coefficients for the heterogeneous treatment effect model. The first thing to notice is that the coefficients for the SES variables (not interacted with PS dummy) are positive[17], and therefore there is an increase in the test scores as students come from less disadvantaged backgrounds, or that the test score-SES slope is positive for both types of schools. This is consistent with previous literature that find that family characteristics matter in school achievement. Additionally, the PS*SES

[16] In theory the gains to "lower-end" students from the voucher system are not exclusive to attending the private schools but to having the possibility to do so. It is this possibility of switching between schools that increases competition and rises overall school quality (public and private). Unfortunately, we do not have data on school quality before the voucher system was implemented and therefore cannot evaluate the impact on education quality as a whole.

[17] Note that the vulnerability index increases as the family is more vulnerable, and therefore a negative coefficient is consistent with having better test scores for schools with less vulnerable students.

interaction coefficients are positive (again except for the vulnerability index by construction) implying that as the socioeconomic characteristics of the students' families get better the increase in test scores in private subsidized schools is higher than in public schools. In other words, the test score-SES slope of the private subsidized schools is larger.

Graph 6 confirms the above findings, and those presented in the raw data analysis, by showing the predicted test scores for private subsidized and public school for 5 representative households. Households 1 to 5 are ranked from least to most rich, educated and invulnerable[18]. The treatment effect (or gain at private subsidized schools) for each representative household is $T_{PS,i}$-$T_{PU,i}$, or the difference between the lines.

Just as the simple plots of the raw data suggested, there is a negative treatment effect on students from less advantaged backgrounds. This negative effect is reduced as the characteristics of the families get better and turns positive for the less disadvantaged families.

In sum, these results suggest that private subsidized schools have a comparative advantage in teaching students from more advantaged background, but not all students as is commonly believed. It will not be beneficial for less educated/income families to put their children in private subsidized schools. In fact, they will do better (on average) in a public school than in a comparable private subsidized school. This raises the question of what do public schools have that makes them "better" than private subsidized schools for low SES students. Or, inversely, what do private subsidized schools do differently that benefit

[18] Household 3 corresponds to the mean household.

students from a higher SES family. These questions can be in part answered by analyzing the coefficients of the school-teacher variables in Table 4.

In general, the sign and magnitudes of the control coefficients show what characteristics are related to better achievement. Additionally, the regression results for each school type show how the different characteristics affect achievement in different ways. In terms of school characteristics, school size, teacher experience, teacher education certification and percentage of female teacher are all positively related to higher test scores. The average number of hours worked by the teachers is negative but not statistically significant.

Additionally, consistent with international evidence and other studies for Chile (Romaguera and Mizala (1998) and Romaguera, Mizala and Farren (1997)), when public and private subsidized schools are considered together, same sex schools have significantly higher average test scores than mixed schools. When looking at the regressions by school type, we find that boys' only private subsidized schools, have better performance than girls only and they both do better than mixed schools. This is not the case for public schools, were girls schools perform better, followed by mixed schools and finally boys schools.

One interesting result is that class size is negatively related to test scores in public schools but positive in private subsidized schools. This can be seen in model IV (i.e. significantly negative class size coefficient and significantly positive and bigger coefficient for class size interacted with PS dummy). It can also be seen from the regressions run on each type of school separately.

One possible explanation (to the different sign in the class size effect), is that public schools are more limited by infrastructure and therefore, increases in school size translate into over-crowded classrooms. Another possibility is that the causal relation goes in the other direction: better schools attract more students and therefore, the classes get larger. It is also possible that better student groups don't need to have personalized attention, as do less advantaged students. Peer effects may be larger in private schools because they are composed of students from better socioeconomic backgrounds, and this effect is relatively stronger than the small class size effect.

As mentioned earlier, the signs of the socioeconomic characteristics coefficients are as expected. Schools with students with higher parental education and income tend to perform better, on average, in the 4^{th} grade achievement test. The coefficient for vulnerability index is negative and significant in all models and samples, implying that schools with more vulnerable students on average do worse. Consistently with previous studies, maternal education matters more than paternal education for achievement.

The above results are also observed in the separate regressions for public and private subsidized schools. Maternal education, vulnerability index, household income, relationship with the poverty line are significant in all specifications. Paternal education is negatively correlated with test scores in public schools but positively correlated in private subsidized schools.

7.2. Case II: Non Random Treatment Assignment

The above results rely on the assumption that selection/sorting into schools is either random or that it depends only on observable characteristics and therefore can be estimated treating them as random conditional on the X's. The results in this section incorporate the possibility of nonrandom assignment to treatment by assuming that $f(\mu_{ps}, \mu_{pu}, \nu)$ is a trivariate normal distribution[19] and using the characteristics of such distribution to compute selection correction terms from a first stage probit regression for the probability of being in a private subsidized school on individual SES variables (presented in table 5). The correction terms are computed from the average predicted probabilities for each school.

Four second stage models are estimated. The first two assume that if students perform better in one type of school they will do so in all types of schools and therefore restricts the ρ's (i.e. correlation between selection/sorting into PS and test scores) to be the same for both types of schools. This is consistent with a 1-factor or absolute advantage model. Within this framework constant and heterogenous effects' models are estimated.

In both cases the ρ's are negative and significant. Thus implying that unobserved selection into private subsidized schools is negatively related to test scores in both private and public schools. Therefore the observed test scores in private subsidized schools is below the expected test score for the population, and the opposite is true for the public school test scores. The OLS treatment effect is downward biased by the omission of selection correction terms.

The second set of estimates does not restricted the ρ's to be equal, to allow for comparative advantage type of sorting into schools. When the treatment effect is assumed to be constant, the coefficients on the selection terms are still negative and significant. Therefore, the average treatment effect from the OLS models are downward biased. But,

[19] See Heckman (1979) for a discussion on the importance and limitations of assuming a normal trivariate

when the interaction terms are included in the model to allow for differential effects along the X's, the selection coefficient for private schools turn positive and non significant indicating that selection into private schools is mostly captured by the interaction terms on the observable characteristics. On the other hand, the selection correction coefficient for public schools is still negative and significant, implying that selection into public schools is unaccounted for by controlling for observables and that it is positively related to test scores in that type of schools. These findings are confirmed when running the regressions for each type of school independently.

The direction of the bias is ambiguous since for both schools we observe upward biased estimates of the population expectations. But since the effect in the public schools is bigger in magnitude and significance it is probable that the uncorrected estimates are less positive and more negative than the corrected effects.

Graph 7 shows the predicted test scores for public and private schools from the estimation of the heterogeneous treatment effect model with unequal ρ's for five representative households. The results are consistent with all previous results suggesting that there is a positive treatment effect only for students that do not come from the worse socioeconomic backgrounds.

8. Conclusions

This paper analyses the relative efficiency of private and public schools by looking at elementary schools in Chile in 1996. By introducing a more detailed set of control variables to account for selection and estimating models with selection correction terms "a

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distribution of the error terms.

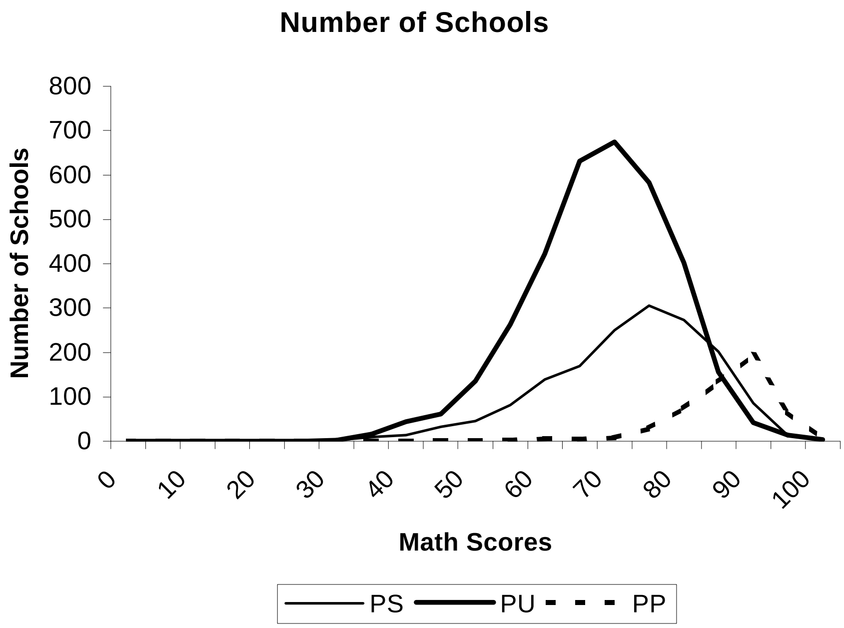
la Heckman" this paper has dealt with the traditional pitfalls of most of the studies of private versus public education: Selection Bias. Moreover, by introducing interaction terms of the observable characteristics and the private dummy it allows for the estimation of heterogeneous treatment effects and its distribution and not just an average treatment effect as all of the previous studies using Chilean data have done.

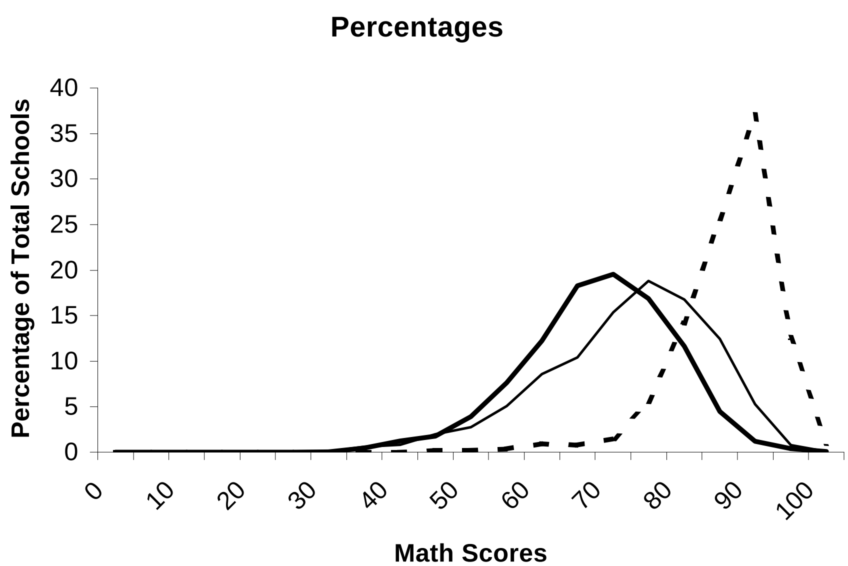
The results suggest that public schools are neither uniformly worse nor uniformly better than private schools. Rather, public schools appear to be relatively more effective for students from disadvantaged family backgrounds. Such a system of comparative advantage is consistent with the observation that public and private schools continue to co-exist in most Chilean communes. Moreover, it is consistent with other features of the Chilean data, including the under-representation of disadvantaged students in the private schools (despite the fact that these schools are free), and in larger class sizes in private versus public schools.

The paper does not analyze the possible reazons why this system of comparative advantage has emerged in the chilean education system. This will be left as the subject of future research.

The findings lead to policy recommendations that differ from those traditionally proposed. Since it is not true that public schools are worse, it is not necessary to eliminate them, as some have suggested. Additionally, since they are an important service to less advantaged kids, not only must we not eliminate them but also design policies focalized on those schools.

Graph #1 Distribution of the Average 4th Grade Math Score by Type of School (1996)



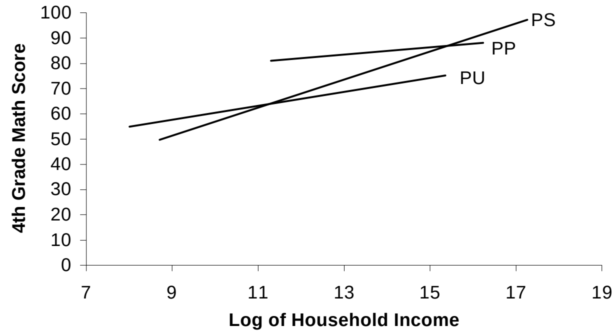


	PS	PU	PP
Average Scores	69	66	84
Std. Deviation	12	10	7

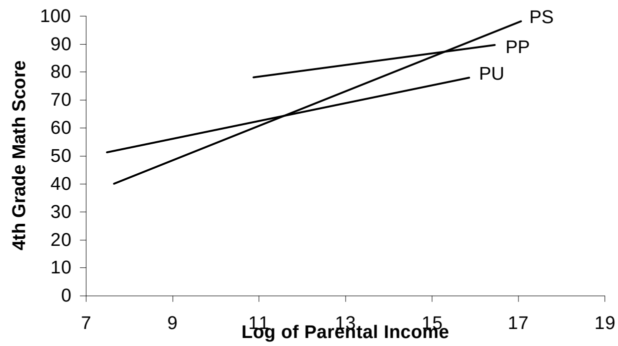
Test for Equal Distributions (Komogorov-Smirnov)		
PU vs PS	1.000	
PU vs PP	0.006	*
PS vs PP	0.010	*

* Reject Equal Distribution at 95% Confidence

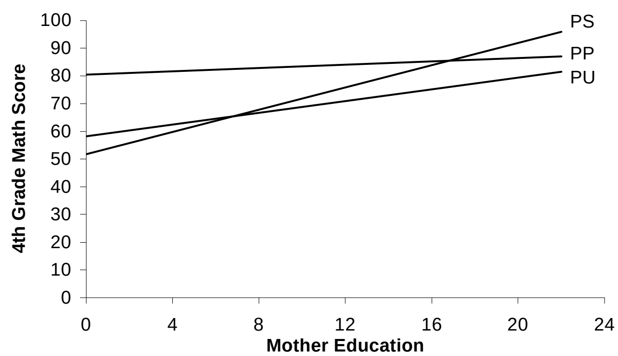
Graph #2 Plot of Math Score * Log Household Income



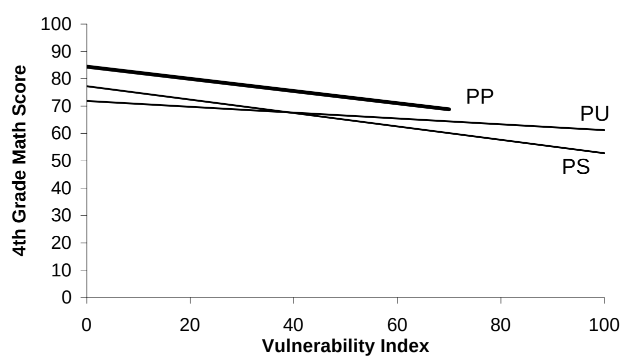
Graph #3 Plot of Math Score * Log Parental Income



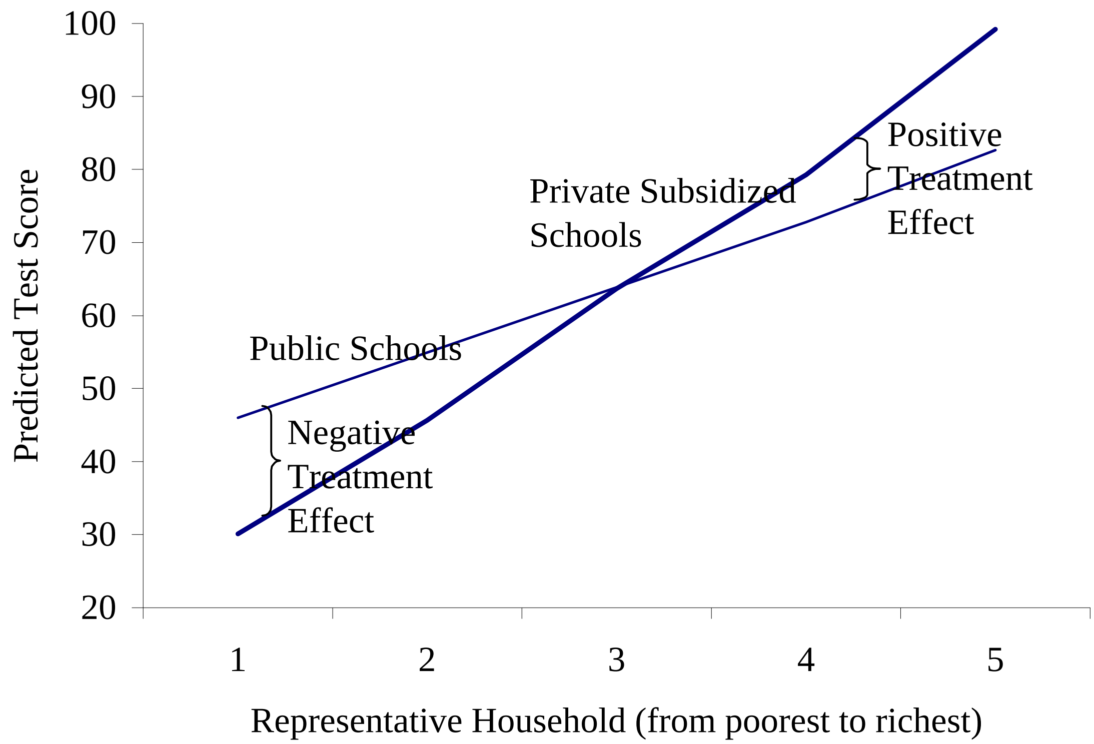
Graph #4 Plot of Math Score * Mother Education



Graph #5 Plot of Math Score * Vulnerability Index



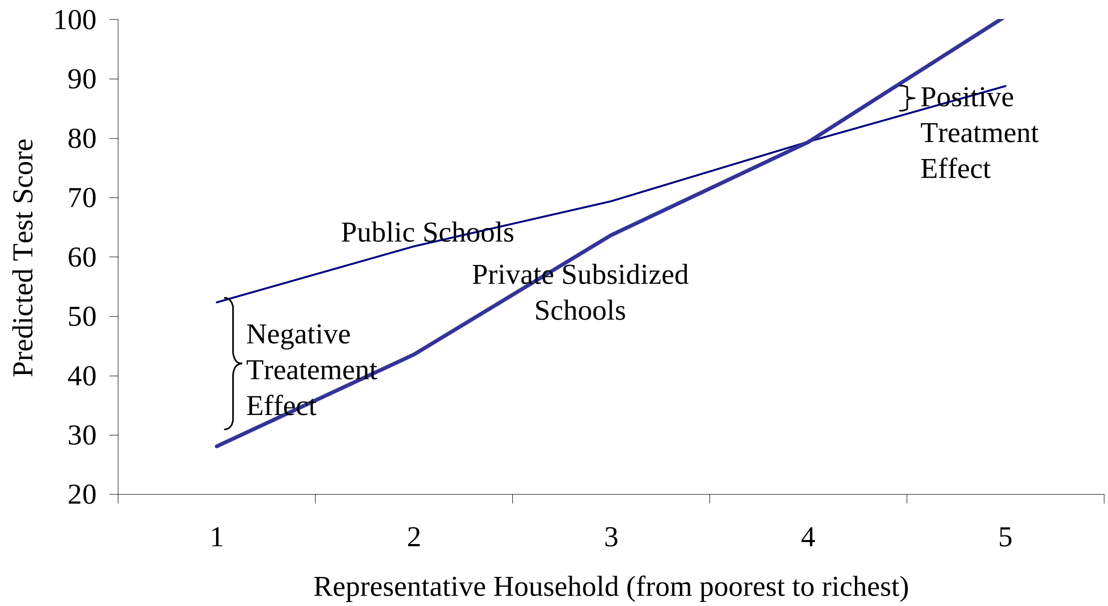
Graph #6. Predicted Test Scores for Five Representative Households
Average School Characteristics for PS and PU Used in Estimation



Representative Household Data

	1	2	3	4	5
Vulnerability Index	100	75	50	25	0
Number of people in the household	10	8	6	4	2
Poverty line index	1	1.5	2	2.5	3
Log of Household Total Income	6	8	12	14	17
maternal education	0	4	8	12	18
paternal education	0	4	8	12	18

Graph #7. Predicted Test Scores for Five Representative Households From the Selection Models
Average School Characteristics for PS and PU Used in Estimation



Representative Household Data

	1	2	3	4	5
Vulnerability Index	100	75	50	25	0
Number of people in the household	10	8	6	4	2
Poverty line index	1	1.5	2	2.5	3
Log of Household Total Income	6	8	12	14	17
maternal education	0	4	8	12	18
paternal education	0	4	8	12	18
Predicted Probability of being a Private School	0	0.25	0.5	0.75	1

Table 1
Sample Means

	Public Schools		Private Subsidized		Paid Private Schools	
	N	Mean	N	Mean	N	Mean
School Characteristics						
rural dummy	3470	0.53	1635	0.21	525	0.12
4th grade enrollment	3470	44.89	1635	53.06	525	39.35
total enrollment	3441	353.28	1547	431.93	470	342.90
% of male only schools	3470	0.01	1635	0.02	525	0.05
% of female only schools	3470	0.01	1635	0.06	525	0.08
4th grade class size	2432	30.06	1313	34.83	465	24.50
class size	2727	31.06	1390	35.60	468	24.08
Teacher Characteristics						
N. of years of teaching experience	3408	18.20	1588	12.60	451	10.96
Hours worked	3409	26.34	1588	24.07	451	23.27
Contractual hours	3409	31.89	1588	28.71	451	28.37
% of teachers with education degree	3409	0.97	1588	0.91	451	0.96
% of male teachers	3409	0.32	1588	0.28	451	0.26
Family Background Characteristics						
Vulnerability Index	3466	59.83	1572	32.39	438	0.62
Number of people in a the household	2337	5.37	1330	5.06	402	4.75
Poverty line index	2336	2.46	1330	2.65	401	2.97
Age of the students	2337	10.34	1330	10.04	402	9.87
Education of the students	2337	4.33	1330	4.21	402	4.20
Dummy for full day school	2337	0.13	1330	0.12	402	0.27
Household Total Income	2033	266699.55	1145	411245.16	334	1678574.51
Maternal total income	2046	88964.40	1162	142515.77	347	563643.99
Paternal total income	2275	179317.01	1280	291994.66	379	1262193.18
maternal education	2322	7.74	1326	9.52	402	13.94
paternal education	2281	7.79	1285	9.82	380	14.67
maternal age	2330	37.91	1328	37.77	402	38.33
paternal age	2289	41.09	1287	40.74	380	41.86
parental education	2331	7.76	1328	9.65	402	14.27
parental total income	2323	253967.87	1322	407985.24	400	1684889.21
Test Scores						
Math	3440	66	1631	69	527	84
Spanish	3422	65	1616	70	523	84

Table 2
Average 4th Grade Test Scores by School Type

		Public		Private Subsidized		Paid Private		RELATIVE DIFFERENCE	
		SCORE	*N. SCHOOLS*	SCORE	*N. SCHOOLS*	SCORE	*N. SCHOOLS*	PS/PU	PP/PU
Average School Parental Education									
NONE	MATH SCORE	59	*34*	57	*17*			-4.0%	
	SPANISH SCORE	60	*34*	58	*18*			-2.5%	
INCOMPLETE	MATH SCORE	66	*1985*	64	*514*	70	*4*	-1.9%	
ELEMENTARY	SPANISH SCORE	66	*1979*	65	*511*	74	*3*	-1.7%	
INCOMPLETE	MATH SCORE	70	*583*	74	*676*	68	*3*	4.2%	
HIGH SCHOOL	SPANISH SCORE	71	*582*	75	*673*	72	*3*	5.2%	
INCOMPLETE	MATH SCORE	78	*40*	79	*225*	75	*8*	1.6%	
COLLEGE	SPANISH SCORE	79	*40*	81	*223*	79	*8*	2.2%	
MORE	MATH SCORE			85	*7*	81	*4*		
	SPANISH SCORE			86	*7*	81	*4*		
MOTHER´S EDUCATION (CASEN)									
INCOMPLETE	MATH SCORE	64	*2364*	63	*634*	80	*126*	-2.2%	20.2%
ELEMENTARY	SPANISH SCORE	64	*2349*	63	*622*	81	*123*	-1.4%	21.7%
COMPLETE	MATH SCORE	65	*91*	69	*46*	76	*5*	6.8%	15.2%
ELEMENTARY	SPANISH SCORE	64	*90*	70	*46*	78	*4*	7.8%	17.2%
COMPLETE	MATH SCORE	66	*51*	74	*69*	82	*53*	10.9%	19.5%
HIGH SCHOOL	SPANISH SCORE	66	*51*	75	*68*	84	*53*	12.6%	21.8%
MORE THAN	MATH SCORE	72	*63*	78	*198*	85	*302*	7.7%	15.2%
HIGH SCHOOL	SPANISH SCORE	74	*62*	79	*198*	86	*302*	7.2%	14.1%
RURAL/URBAN									
0	MATH SCORE	68	*1643*	72	*1277*	84	*462*	5.6%	19.3%
	SPANISH SCORE	68	*1639*	73	*1271*	85	*458*	6.3%	19.6%
1	MATH SCORE	64	*1797*	62	*354*	82	*65*	-3.3%	22.2%
	SPANISH SCORE	63	*1783*	62	*345*	83	*65*	-2.3%	24.0%
GIRLS SCHOOL									
	MATH SCORE	72	*51*	79	*94*	86	*43*	8.7%	15.8%
	SPANISH SCORE	74	*50*	82	*94*	87	*43*	9.0%	15.1%
BOYS SCHOOL									
	MATH SCORE	71	*31*	81	*32*	86	*30*	12.6%	17.6%
	SPANISH SCORE	71	*29*	81	*32*	86	*30*	11.9%	17.5%
VULNERABILITY INDEX									
1	MATH SCORE	73	*278*	76	*765*	84	*523*	4.0%	13.2%
	SPANISH SCORE	74	*276*	77	*762*	85	*520*	4.4%	12.7%
2	MATH SCORE	68	*855*	69	*405*			1.9%	
	SPANISH SCORE	68	*855*	70	*400*			2.2%	
3	MATH SCORE	66	*667*	62	*184*	60	*2*	-4.8%	
	SPANISH SCORE	65	*666*	63	*185*	63	*1*	-4.8%	
4	MATH SCORE	65	*504*	59	*97*	73	*2*	-11.1%	
	SPANISH SCORE	65	*501*	59	*94*	73	*2*	-9.9%	
5	MATH SCORE	62	*1136*	56	*180*			-10.5%	
	SPANISH SCORE	61	*1124*	55	*175*			-10.8%	
4TH GRADE CLASS SIZE									
<16	MATH SCORE	63	*1197*	61	*373*	80	*143*	-2.6%	21.0%
	SPANISH SCORE	62	*1184*	61	*364*	81	*139*	-0.9%	23.6%
>15 & <31	MATH SCORE	66	*947*	69	*337*	84	*269*	4.1%	21.8%
	SPANISH SCORE	66	*944*	70	*335*	85	*269*	5.2%	22.4%
>30	MATH SCORE	68	*1205*	73	*883*	86	*100*	7.2%	21.4%
	SPANISH SCORE	68	*1203*	74	*879*	87	*100*	7.9%	21.5%

Note: When sample size is too small, the relative difference is not computed.

Table 3

Impact of Sequentially Including Controls on the Estimated Intercept

Difference between Private Subsidized and Public School Production Functions

	PS coef.	std error	F-stat	R2 adj
URBAN + RURAL Private Subsidized and Public Schools N=2789				
Uncontrolled	4.07	0.45 *	82.65 *	0.03
School Controls	4.77	0.52 *	37.65 *	0.12
SES Controls	-0.14	0.50	75.67 *	0.30
Interactions Included	-29.10	9.22 *	58.67 *	0.32
URBAN Private Subsidized and Public Schools N=2219				
Uncontrolled	4.36	0.24 *	140.97 *	0.06
School Controls	6.32	0.43 *	59.29 *	0.19
SES Controls	2.01	0.42 *	85.70 *	0.36
Interactions Included	-22.87	6.75 *	67.45 *	0.39
RURAL Private Subsidized and Public Schools N=569				
Uncontrolled	-0.35	1.37	0.07	0.00
School Controls	1.02	1.52	3.57 *	0.04
SES Controls	-0.17	1.44	7.91 *	0.15
Interactions Included	-38.02	29.27	6.20 *	0.16

Note: First three rows of each panel have no interaction terms and the PS coef is the vertical distance between parallel production functions (i.e. constant additive treatment effect). The fourth row is the PS coeficient for the model with interactions of PS with Xi and corresponds to the vertical distance between non-parallel production function at the y axis.

* = statistically significant with 95% confidence.

Weights= Number of students form CASEN/total enrollment

Table 4
OLS Regresion Results

Variable	Sample: Public and Private subsidized Schools — MODEL I Coef	MODEL I S.E.	MODEL II Coef	MODEL II S.E.	MODEL III Coef	MODEL III S.E.	MODEL IV Coef	MODEL IV S.E.	Sample: Private Subsidized Schools Coef	Sample: Private Subsidized Schools S.E.	Sample : Public Schools Coef	Sample : Public Schools S.E.
intercept	66.58	0.22 *	59.12	2.19 *	47.23	4.60 *	58.59	5.33 *	31.83	5.93 *	59.03	6.21 *
private subsidized dummy	4.07	0.45 *	4.77	0.52 *	-0.14	0.50	-29.10	9.22 *				
rural dummy			0.37	0.48	2.49	0.50 *	1.50	0.53 *	5.58	1.03 *	1.44	0.61 *
class size			-0.13	0.02 *	-0.15	0.02 *	-0.20	0.02 *	0.06	0.03 *	-0.20	0.02 *
male school			6.98	2.03 *	2.80	1.81	1.68	1.79	4.65	1.75 *	-0.55	2.96
female school			5.99	1.22 *	3.67	1.09 *	2.41	1.08 *	1.55	0.99	2.51	2.01
number of teachers			0.24	0.02 *	0.07	0.02 *	0.07	0.02 *	0.06	0.03 *	0.07	0.03 *
N. of years of teaching experience			0.07	0.03 **	0.03	0.03	0.04	0.03	0.05	0.03	0.04	0.04
Hours worked			-0.05	0.03 *	-0.02	0.03 *	-0.01	0.03	-0.04	0.04	-0.01	0.03
% of teachers with education degree			9.33	1.99 *	9.82	1.77 *	8.18	1.77 *	9.16	1.99 *	7.25	2.58 *
% of male teachers			-3.90	1.16 *	0.31	1.05	-0.20	1.04	-7.84	1.63 *	1.79	1.32
Vulnerability Index					-0.11	0.01 *	-0.11	0.01 *	-0.13	0.02 *	-0.11	0.01 *
Number of people in a the household					-0.92	0.22 *	-0.95	0.21 *	-1.09	0.31 *	-0.91	0.27 *
Poverty line index					4.76	0.61 *	5.17	0.68 *	2.38	0.94 *	5.21	0.77 *
Log of Household Total Income					0.41	0.40	-0.05	0.47	1.40	0.50 *	-0.09	0.54
maternal education					1.20	0.14 *	1.09	0.16 *	1.24	0.20 *	1.12	0.18 *
paternal education					-0.29	0.13 *	-0.61	0.15 *	0.32	0.17 **	-0.62	0.17 *
private subsidized dummy interactions												
class size							0.26	0.04 *				
rural dummy							3.93	1.52 *				
Vulnerability Index							-0.03	0.03				
Poverty line index							-2.12	1.44				
Log of Household Total Income							1.29	0.82				
maternal education							0.21	0.31				
paternal education							0.89	0.28 *				
N	2789		2789		2789		2789		982		1806	
R2	0.03		0.12		0.3		0.32		0.55		0.21	

Note: * is significant at 95% confidence level. ** is significant at 90% confidence.
Weights=Number of students from Casen/Total enrollment

Table 5. Probit Results

Variable	Parameter Estimate	Standard Error	
INTERCEPT	-2,16	0,15	*
RURAL	-0,99	0,05	*
HHINC	0,00	0,00	*
MEDUC	0,08	0,01	*
FEDUC	0,07	0,01	*
NUMPER	-0,08	0,01	*
POVERTY	0,25	0,03	*
SEXO	-0,08	0,03	**
EDUC	0,04	0,02	**
EDAD	-0,04	0,02	**
N		19883	
Concordant		71,00%	
Discordant		28,70%	
Tied		0,30%	

* : statistically significant at 99% confidence

** : statistically significant at 95% confidence

Table 6
Selection Correction Coefficients in the Heckman Selection Models

	lps		lpu		F-stat	R2 adj
	coef	st error	coef	st error		
Absolute Advantage Model: Equal Covariance Between Selection and Test Scores						
Constant Treatment Model	-20.27	6.25 *	-20.27	6.25 *	64.11 *	0.29
Heterogenous Treatment Model	-19.16	6.18 *	-19.16	6.18 *	50.81 *	0.31
Comparative Advantage Model: Unequal Covariance Between Selection and Test Scores						
Constant Treatment Model	-33.10	7.66 *	-16.47	6.39 *	61.19 *	0.29
Heterogenous Treatment Model	6.73	11.89	-28.22	7.12 *	48.13 *	0.31
Private Schools Only	1.76	8.57			65.19 *	0.52
Public Schools Only			-28.60	8.10 *	30.14 *	0.21

Note: Constant treatment effect models are those with no interaction terms of PS with X. The heterogenous model includes interactions of PS with the deviation of the X's from its

* = statistically significant with 95% confidence.

Weights= Number of students from CASEN/total enrollment

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