

Using School Scholarships to Estimate the Effect of Government Subsidized Private Education on Academic Achievement in Chile¹

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Abstract

This paper estimates the impact of private education on low-income students in Chile. We attempt to reduce selection bias by using reduced-tuition paying, low-income students in private schools as the treatment group, based on our finding that these students were, to some extent, randomly selected out of the public school control group. Propensity score matching is then used to calculate the difference in academic achievement of students in the treatment group versus their counterpart in the control group. Our results reveal that students in private voucher schools with tuition score slightly higher than students in public schools. The difference in standardized test scores is approximately 8 points, a test score gain of almost 0.15 standard deviations.

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I. Introduction

School choice is a topic of vigorous debate among academics and policy makers worldwide. The fundamental theory behind school choice is that private schools are more efficient than public schools; therefore, giving parents the option of sending their children to private schools creates a competitive market that improves the quality of both private and public schools. There have been many evaluations of experimental school choice programs, such as the Milwaukee Parental Choice Program (Rouse, 1998; Greene, Peterson and Du, 1998), the New York City school voucher experiment (Howell and Peterson, 2002; Krueger and Zhu, 2004), and the PACES program in Colombia (Angrist et. al, 2002).² The findings of these studies suggest that offering vouchers leads to small improvements in test scores, although the effects depend on gender and race and are sensitive to important decisions about the sample used in the study.

Of all of the school voucher experiments that have been conducted, Chile stands out because it is one of the few countries in the world that has had a universal voucher system intact for over twenty years.³ In contrast to voucher programs that are limited to a certain number of students who are selected to participate, Chile's school choice program gives all students the option of attending private schools that are subsidized by the government with a per-student voucher. This paper uses the Chilean educational system to estimate the effect on academic achievement that results from randomly moving a student from a public to a private voucher school.

There are several important challenges that must be addressed when estimating the academic effects of private education. The first is a missing data problem: it is impossible to simultaneously observe the outcome of a student that attends a private voucher school as well as the outcome of that same student attending public school. Another challenge addressed in this paper is selection bias. In Chile, although all students have the option of attending private voucher schools, those that choose to take advantage of the vouchers may have unobserved characteristics that are correlated with academic achievement. Furthermore, past research indicates that an additional bias may arise from the manner in which some private voucher schools select the students (Gauri, 1998; McEwan, 2001; and Hsieh and Urquiola, 2003).

² The Colombian program PACES is a large scale program that awarded secondary school vouchers to more than 125,000 low-income students in public schools.

³ The Netherlands and Sweden are other examples of countries with universal voucher systems.

While public schools are obligated by law to admit all students that apply, private voucher schools are free to be selective in their admissions process.

We have taken a two-step approach to deal with the econometric issues discussed above. The first is to use the provision of scholarships for low-income students to attend private voucher schools as a method of reducing the selection bias that occurs in private school education. Since 1993, private voucher schools have been allowed to charge tuition on top of the voucher; however, schools that charge tuition must allocate a percentage of the tuition to scholarships for low income students. When awarding the scholarships, schools tend to give preference to the children of families going through a period of economic difficulty and to the sons and daughters of school employees. The children of school employees (such as the school administrators, janitors, etc.) often display characteristics typical of students in public schools because had these children not been given scholarships, their families would have probably sent them to a public school. This paper uses scholarships to identify these types of students for the treatment group because they were, to some extent, randomly selected out of public schools and into private voucher schools.

The second step of our approach is to use propensity score matching as an econometric estimator of the impact of private voucher school education on academic achievement. Matching allows us to infer the public school outcomes for scholarship students in private voucher schools with tuition and use this information to estimate the average treatment effect on the treated students. Dehajia and Wahba (2001) show that this method yields accurate estimates of the treatment effect in non-experimental settings where corrections for sample selection bias due to observable differences between treatment and comparison groups are needed. In this paper, we use propensity score matching to directly compare the test scores of low-income students in private voucher schools that charge tuition with those of similar students in public and private voucher schools without tuition.

Our results reveal that students in private voucher schools with tuition score slightly higher than students in public schools. The difference in scores in the standardized tests is approximately 8 points, a test score gain of almost 0.15 standard deviations. A similar result was obtained by Angrist et al (2002) when comparing test scores of lottery winners and losers in the PACES program in Colombia. Moreover, in an analysis of ten Latin American countries, Somers, McEwan and Willms (2004) find an average private school effect of 0.3 standard deviations after controlling for individual characteristics such as

socioeconomic status. They find that this average effect drops to 0.04 standard deviations after controlling for the mean socioeconomic status of peer groups.

We also compare the performance of students in private voucher schools with tuition to students in private voucher schools without tuition, but the results are not conclusive. In most cases, there appears to be no difference in test scores, although at times, students in private voucher schools with tuition appear to very slightly outperform students in private voucher schools without tuition. We do not include students in private non-voucher schools in the analysis because these schools typically only serve the most elite families in Chile. Private non-voucher schools are not a reasonable educational option for the average student in Chile because the average tuition charged at private non-voucher schools is more than three times the per-student voucher paid by the state and much higher than the tuition charged at private voucher schools with tuition.

The paper is organized as follows: Section II provides a general overview of the Chilean educational system and reviews the recent literature on school choice in Chile. Section III explains our identification strategy. Section IV describes the data sources used in this study. Section V discusses the methodology, and presents our main results and a number of robustness checks. Section VI provides the conclusion.

II. The Chilean Educational System⁴

In the early 1980s sweeping reforms were made to Chile's educational system, in which the public sector school system was decentralized and school management was delegated to local government authorities. A system of standardized tests for measuring educational attainment, known as the SIMCE (Educational Quality Measurement System), was established to evaluate the success of the reforms, inform parents about the quality of their schools, and provide a basis for future political decision. The reform also paved the way for the private sector to enter the market as a provider of education by introducing a voucher-type demand subsidy to finance municipal and private voucher schools. The voucher, which is paid directly to schools on a per-student basis, is intended to cover running costs and generate competition between schools to attract and retain students, thus promoting more efficient and better quality education services.

⁴ A large portion of this description of the Chilean educational system is from Mizala and Romaguera (2000).

Since 1993, private voucher schools have been permitted to charge students a nominal tuition on top of the voucher that is received from the state. The conditions under which a school may charge students tuition are that 1) the amount of the voucher is reduced according to the tuition charged and 2) the schools allocate a percentage of the tuition charged, in addition to a percentage of the voucher money that is given by the state, to a scholarship fund for students. Two-thirds of the scholarships must be given to students based on their economic need, while the remaining third may be distributed at the discretion of the school.⁵ Table 1 shows the amount of the voucher that schools are eligible to receive depending on the tuition charged, the number of schools operating in Santiago that charge each tuition amount, as well as the amount of money allocated for scholarships. As shown in the table, any school that charges over 4 USE (Unidad de Subvención Escolar)⁶ per month in tuition (roughly \$80) does not receive a subsidy from the government and is considered a private non-voucher school.⁷

As a result of these reforms, the number of new schools in the private sector has increased rapidly over the past fifteen years. In 1985, there were 2,643 private voucher schools in Chile; this number grew to 3,640 in 2002 and to 4,084 in 2003. The resulting four-legged school system comprises of:

1. Private non-voucher schools, which are financed by fees paid by parents and guardians. In 2002, approximately 8.5 percent of all students in Chile attended private non-voucher schools.
2. Private voucher schools with tuition, which are co-financed by the per-student voucher provided by the government and the monthly tuition paid by the parents. These schools are run by the private sector and account for 25.3 percent of total enrollment.
3. Private voucher schools without tuition, which are financed by the per-student voucher provided by the government, but are owned and run by the private sector. These account for 12.5 percent of total enrollment.
4. Public schools, which are also financed by the voucher but are owned and managed by municipal authorities. They represent 52.1 percent of the enrollment.

The remaining 1.6 percent of the school population attend schools run by educational corporations linked to business organizations or schools governed by Decree 3166, which administers professional-technical

⁵ In section V, we go into greater detail about the characteristics of the students that receive scholarships.

⁶ USE is the monetary unit used for distributing the vouchers to schools.

⁷ USE (Unit of student subsidy) is the monetary unit used for distributing the vouchers to schools. In 2002, the value of the USE was 11,747 pesos although this figure is re-adjusted every year.

secondary schools belonging to the Ministry of Education with lump-sum financing granted in a concession contract.

Although the private voucher school sector has grown significantly, the distribution of this type of school throughout the country is uneven. In general, there are very few private schools in rural areas, and nearly 90 municipalities have no subsidized private schools at all. Of the total enrollment in rural areas, municipal schools account for 77.7 percent, private voucher schools 20.3 percent and private non-voucher schools 1.3 percent.

Recently there has been interest in academic circles in studying the effects of the Chilean school choice system on the quality of education provided. The Chilean literature on the effects of attending a private voucher school is non-experimental because parents are free to choose whether to participate or not and schools are free to be selective in their admissions.

Until 1998, data on socio-economic characteristics were only available at the school level; as a result, all research conducted on the subject used the school as the level of analysis. McEwan and Carnoy (2000) concluded that on average, non-religious private voucher schools produce lower academic achievement than similar students in public schools, whereas Catholic private voucher schools produce higher achievement by spending more money than their non-religious counterparts. In contrast, Mizala and Romaguera (2000) argued that when sufficient control variables are included in the regression, there is no consistent difference between the tests results observed in public schools relative to private voucher schools. Similarly, Tokman (2002) found that public schools are not consistently better or worse than private schools, although public schools did show evidence of being more effective for students from disadvantaged family backgrounds.

Student level analysis became possible in 1998, when the Ministry of Education began to administer a questionnaire to all the parents of students who participated in the country's annual standardized SIMCE test. After integrating the student level socio-economic questionnaire data in his analysis, McEwan (2001) found no consistent difference between student achievement in public and non-religious private voucher schools, although private non-voucher and Catholic voucher schools still produce higher achievement than public schools. In contrast, both Mizala and Romaguera (2001) and Sapelli and Vial (2002) found that private voucher schools produce higher academic achievement than public schools. The difference found

by Sapelli and Vial was even larger when they account for the schools' differences in the amount of the per-student resources.

This brief literature review demonstrates that despite the wealth of research that has been conducted on this subject, there is no consensus on the difference in academic achievement produced by attending a private voucher versus a public school.⁸ The discrepancy in outcomes can primarily be attributed to differences in the aggregation level of the data (student vs. school level data), the tests considered (year and grade), the size of the school samples, the methodology used to evaluate school performance (with or without correction for selection bias), and the instrumental variables used to correct for selection bias (for example, the number of public and voucher private schools in the neighborhood, the ratio of students in private voucher schools over the total number of students in schools financed by the state, or the reasons parents report about how they choose a school for their children, such as proximity to home and school's values). The wide range of results is not specific to the Chilean case; a similar lack of consensus about the impact of private school vouchers can be found for other countries (McEwan, 2004).

This study is innovative in a number of important respects. First of all, it uses an identification strategy that reduces the selection bias that has posed a significant challenge to past studies that estimate the effect of private education. Moreover, it uses propensity score matching to identify comparable treatment and control groups. As stated earlier, this method alleviates the bias due to systematic differences between the treated and comparison groups (Dehejia and Wahba, 2001). Finally, it is the first study to differentiate between private voucher school with and without tuition and compares their academic performance.

In the next section, we explain how the provision of school scholarships creates a natural experiment that allows us to measure the effect of government subsidized private education on academic achievement in Chile.

III. The Identification Strategy

As stated previously, the goal of this paper is to estimate the average effect on academic achievement that results from randomly moving a student from a public to a private voucher school with tuition. We

⁸ There also exists a related literature that analyzes whether vouchers encourage sorting (Hsieh and Urquiola, 2003). Other literature studies whether vouchers promote competition in the educational system, improving test results (Gallego, 2002, 2005).

consider private voucher school education to be the treatment, and the evaluation parameter that we focus on is the average effect of the treatment on the treated. Since it is impossible to observe the same student in two different school types, we use a methodology that allows us to infer the academic achievement that would be produced if a private voucher school student had instead attended a public school. We also attempt to account for selection bias, which results from the fact that students are free to choose what type of school they would like to attend and private voucher schools are free to be selective in their admissions.

Scholarships give students that would normally attend public schools or private voucher schools without tuition the opportunity to attend private voucher schools with tuition. If these scholarships are uncorrelated with the academic achievement of students, then they can be used to perform a quasi-experimental research design that compares the educational outcomes of scholarship and non-scholarship students.

There is strong qualitative and quantitative evidence that scholarships are awarded to provide incentives for low-income students to attend private voucher schools with tuition in a manner that is independent of student ability. First of all, in order to gain a better understanding of the scholarship system, we conducted interviews with school directors, social workers, and other important participants in the Chilean education system. The interviews were conducted from October 2004 through January 2005 and included visits to 9 private non-voucher schools, 11 private voucher schools, and 1 association of private schools in Chile. The interviews revealed that the two primary reasons for which schools award scholarships to students are either that their family is going through a period of economic difficulty or that they are the son or daughter of a school employee⁹. Particularly the latter category of students is of interest because 1) children of school employees (such as the administrators, janitors, etc.) often display characteristics typical of students in public schools; 2) it is likely that had these children not been given scholarships, their families would have sent them to a public school and 3) they are usually given a preference during the student selection process or in many cases, are automatically admitted into the school. This preference eliminates the selection bias observed by Gauri (1998), McEwan (2001) and Hsieh and Urquiola (2003), who all

⁹ School interviews also revealed that some schools tend to award scholarships based on financial need only to students who are in the ninth grade or older. The primary reason for this preference is that older students will be graduating in a few years and will not need the financial assistance for a long period of time. Moreover, students who have spent more years at the school are better known by the school administrators and therefore, are more likely to receive a scholarship. Although our database is for fourth graders, our logit results discussed in section V below show that the number of years the student has attended a school is effectively a key determinant of scholarship award.

suggested that private schools select students with unobserved characteristics that are correlated with high academic achievement. Moreover, as shown in section V below, logit regressions estimating the probability of scholarship award show that there is no statistically significant correlation between standardized test scores and scholarships. Finally, we use the achievement test scores on fourth graders because at this young age, the schools are less likely to precisely evaluate the abilities of the students.

Unfortunately, the sons and daughters of school employees can not be directly identified in our database. Some scholarships might be awarded to students that are suffering short-term financial problems, such as an illness in the family or temporary unemployment. This concern is particularly relevant for those schools that have a minimum number of years that the student must attend the school before they are permitted to apply for a scholarship. Ideally, these students would not be included in the treatment group since we are interested in students whose decision to attend the school was largely influenced by the scholarships. Unfortunately, it is impossible to distinguish the longevity of the financial problems. To partially account for this problem, in our matching procedure we control for the level of education of the parents by only including students whose parents have less than a university degree in both the treatment and control groups. Parents with low income and high education are most likely suffering a transitory income drop. Thus this exclusion removes a number of observations that may not represent valid treatment cases.

The exclusion of students with parents with high levels of education also solves a second concern: it allows us to eliminate scholarship students whose parents are teachers at the school. There are several reasons why these students should not remain in the treatment group. First of all, while it is unlikely that a teacher's salary is high enough to pay private school tuition, teachers are well educated and have often exceptionally invested in the education of their children. These characteristics of the children of teachers distinguish them from most children who attend public schools and make them unsuitable to be considered in the treatment group.

Other caveats have the potential to limit the validity of scholarships in our identification strategy. First, it is possible that the most motivated parents look for jobs at schools that award scholarships to offer their children the education that private voucher schools with tuition provide. This is an unlikely strategy, as high unemployment rates in Chile over the past few years reduced the bargaining power the typical school worker had. For instance, according to the University of Chile Employment Survey (2003), the aggregate

unemployment rate reached 12.7 percent in years 2000-2001 and the unemployment rate of workers in service sectors was 10.8 percent.¹⁰

An additional concern refers to whether parental motivation is affected by the scholarship. For instance, the possibility of losing the scholarship gives parents an incentive to focus more on school. Similarly, school employees might care more about their children's performance due to reputation concerns. In our estimation procedure below, we add parental input variables in our logit model for the probability of receiving scholarships to account for this potential problem.

Finally, it is highly unlikely that administrators and teachers engage in activities that increase the test scores of the children of school employees. First of all, schools and parents only observe average test scores, as the information on each child's performance is not publicly available. Secondly, the test is administered by public officials and graded by external institutions. Although there could be incentives to inflate the school's test scores, as observed in Jacob and Levitt (2003), there are no reasons to believe that scholarship students are systematically favored by cheating practices.

With these caveats in mind, in this paper we use the provision of scholarships for low-income students to attend private schools to identify the effect of private education on student outcomes, a strategy that is valid as long as these scholarships are distributed independently of academic ability and also influence the decision to attend a private voucher school. This phenomenon creates a somewhat randomized treatment group because most of these students would have been likely to attend a public school had they not been allowed to pay a reduced tuition. In the following section, we will describe the data used in this study, followed by an empirical evaluation of the robustness of using school scholarships to create a natural experiment.

IV. Data

The empirical data used in this study come primarily from two sources. The first source is a standardized test called the SIMCE, which is administered annually throughout Chile to a specified grade level that rotates every year between the fourth, eighth, and tenth grades. This paper uses the 2002 SIMCE data, which was administered to fourth graders. The young age of the students in the database reduces the

¹⁰ We use the 2002 SIMCE database to perform our analysis.

possibility of endogeneity when using school scholarships to estimate differences in academic achievement because schools have very little evidence of the student's academic abilities to consider when awarding scholarships. In contrast, older students have much longer academic records that schools may use as criteria for receiving a scholarship.

The second data source is the questionnaire that is answered by the parents of students that participated in the SIMCE in 2002. This questionnaire provides information on the socio-economic characteristics of each student, such as their family income and the education of the parents, as well as their educational history. Although it is not mandatory for parents to complete the questionnaire, there is an extremely high response rate for most of the key variables used in this analysis.¹¹

In addition to these two primary database, we also used data from the Ministry of Education and the Sub-secretary of Regional Development to calculate the per pupil resources that were available to each school, a principal survey from 1999 to determine the religious affiliation of schools, a list of the schools that were registered in 2000 by the Ministry of Education to determine which schools were new in 2002, and the 2000 SIMCE data to calculate a ranking for all schools and for private voucher schools.

Once these data sources were combined into a comprehensive database, several modifications were made to target the population that we are interested in studying. First of all, the average age for a student in fourth grade is 10 years old; consequently, all students that reported being younger than 6 years old or older than 14 years old were removed from the database. Secondly, we only analyze students that reside in Santiago because this is the region in Chile where students have the greatest opportunity to attend private voucher schools. Particularly in rural areas or smaller urban areas, students have limited school choice as a result of geographic and other constraints. Finally, as mentioned earlier, we chose to exclude students in private non-voucher schools from the analysis because these schools typically only serve the most elite families in Chile. Private non-voucher schools are not a realistic educational option for the average student in Chile because the average tuition charged at private non-voucher schools is over three times the per-student voucher paid by the state and much higher than the tuition charged at private voucher schools with tuition.¹²

¹¹ For students in Santiago that have SIMCE scores available, the response rate for the key student-level variables used in this analysis ranges from 79 percent to 93 percent.

¹² We conducted the analysis including students in private non-voucher schools to see how including these students would alter the results. The results for private voucher schools did not change dramatically from those presented

Modifications were also made to some of the variables in the database in order to make them compatible with our analyses. For example, on the parental questionnaire, parents reported the highest level of education that they had attended. These levels were converted into the corresponding number of years they had been in formal education: the maximum time a parent could spend in basic education is 8 years, high school is 12 years, professional or technical institute is 16 years, college is 17 years, a masters degree is 19 years, and a doctoral degree is 22 years. Parents also reported their monthly income and the amount of tuition they pay for the school as a range (for example, a parent could report that their income is between 400,000 to 500,000 pesos and they pay between 5,000 to 10,000 pesos each month in tuition). These ranges were replaced with the midpoint of the range, which means in the prior example the parent would have an income of 450,000 pesos and pay 7,500 pesos per month in tuition. Furthermore, the income was divided by 100,000 to simplify the interpretation of results. The monthly tuition charged by the school was calculated as the mode of the tuition reported by parents of students that attend the school. Some estimated observations were confirmed through telephone calls to a selection of private voucher schools. The number of years that the child had been in the school was calculated from a variable in which the parents indicated the grade level that the student first attended the school. This calculation may be an underestimation if the student has repeated a grade; however, this should not be a problem since this variable is only used to test the hypothesis that students that have attended the school longer are more likely to receive school scholarships. Table 2 provides a complete list of variables used in this paper, along with their definition and data source, Table 3 summarizes the basic statistics for these variables, and Table 4 presents some basic statistics by school type in order to characterize the different kinds of schools in the Metropolitan Region of Santiago.

V. Empirical Strategy and Results

We estimate the effect of private voucher with tuition education on student performance in a three step strategy. First we estimate a model for the probability of receiving a scholarship. Then, we estimate a school choice model that controls for the likelihood of being awarded a tuition reduction. Finally, we match propensity scores to compare the outcomes of students in the treatment and control groups.

here. However, the results for private non-voucher schools were highly imprecise because only 15 students with complete scores and background variables information had a scholarship in this type of schools.

a. Who receives a scholarship?

Scholarships are awarded on the basis of a number of family and student characteristics. According to the results of school interviews, schools tend to offer tuition reductions to the children of employees, low income students, and students who have attended the school for many years and their families are suffering a temporary drop in income.

For the main analysis, a school scholarship is defined as a 50 percent or more reduction in the tuition. A robustness check is conducted later that defines scholarships as a reduction in the tuition that is equal to or greater than 5 percent of the family's monthly income.

We conduct a maximum-likelihood model to identify the characteristics of students that are likely to receive a scholarship to a private voucher school with tuition. The results can be found in table 5 and reveal that, as would be expected, students likely to receive scholarships have lower family income, this effect of income is non linear. Students who are older than their peers, have attended the school for a greater number of years, have siblings who attend the school, whose parents have lower educational expectations for them, or have not attended preschool also tend to be awarded scholarships more often. This finding is consistent with the results of school interviews that older students that have been in the school for longer periods of time have an advantage in being awarded a scholarship. Finally, students who attend religious or higher ranked schools are more likely to receive a scholarship than those who attend non-religious schools.

To test whether scholarships are awarded on the basis of academic achievement, we re-estimated our logit models including the student's SIMCE scores as an explanatory variable. Two separate logits were estimated: one for private voucher schools that charge tuition and another for private voucher schools that charge tuition and were ranked in the top 10 percent of schools in Santiago in 2000. This second logit was conducted based on the observation that there is more demand for higher ranked schools and therefore scholarships may be more selectively distributed to students. Table 6 shows the results using both language and science SIMCE (which includes the natural and social sciences). We see that there is no statistically significant correlation between language or science SIMCE scores and the probability of obtaining a scholarship in both all schools and schools that rank in the top 10 percent of all private

voucher schools in Santiago.¹³ It is important to recognize that this model is not intended to show the direction of the relationship between SIMCE scores and scholarships; rather, it is intended to identify whether a relationship exists or not. It is also important to recognize that the SIMCE scores are from the same year that the scholarship was awarded. While it would be preferable to have a measure of the student's academic performance prior to receiving the treatment, unfortunately, this type of pre-treatment outcome measure is not available. With these limitations in mind, we can conclude that SIMCE scores are not a significant predictor of being awarded a scholarship, which indicates that schools do not tend to use academic achievement as a criterion in awarding scholarships to students.

b. School choice

Having predicted the likelihood that any particular student will receive a scholarship, we next estimate a multinomial logit model for school choice to calculate a propensity score for each student. Each student has three choices for school type: public school, private voucher school without tuition and private voucher with tuition. The model considers a number of variables as controls that include school and student characteristics, as well as the predicted probability of a scholarship. The variables that we use in the multinomial logit, but are not included in the estimation of the probability of a scholarship are the total number of schools and the number of private schools in the student's neighborhood of residence, a second degree polynomial in the average education of mothers in the school to account for peer effects, and the reasons the parents listed for choosing the school. The variables that we use to estimate the probability of a scholarship that are not included in the multinomial logit are whether the student has siblings that also attend school, the standard deviation of income within the school, the student's distance from the school's average income, the school's rank in 2000, whether the school is new, and the number of years the student has been at the school.

The results of this model, displayed in table 7, show some interesting characteristics of students in each school type. The negative coefficient for the probability of a scholarship to a private voucher school for both types of private voucher schools indicates that students that have a high probability of a scholarship

¹³ The analyses using math SIMCE scores have not been included because we found a significant, positive relationship between the math SIMCE scores and the probability of receiving a scholarship in private voucher schools when the data on all schools was used; however, this relationship was not significant in the top 10% of private voucher schools in Santiago. These results are unusual because one would expect the top 10% of private voucher schools to be more selective with their scholarships than all the private schools together. Given that this correlation invalidates the use of scholarships to identify treatment and control groups, we focused the analysis on language and science SIMCE scores.

have characteristics that are more typical of public school students. Having controlled for the probability of scholarship to a private voucher school with tuition we find that students with a high income are less likely to attend private voucher schools than public schools, whereas those who pick their school due to socio-cultural reasons or values are more likely to go to private voucher schools. Also, students are more likely to attend private voucher schools whenever there are more private schools in their neighborhood. Students are also more likely to attend private voucher schools that are religious and where the mothers of the students in the school have more years of education, which may reflect a desire for anticipated peer effects on their children.

c. Propensity score matching and the average treatment on the treated

The coefficients that are produced in the multinomial logit model are used to calculate a propensity score for each student, which reflects each student's probability of attending private voucher schools with tuition. We then use propensity score matching to estimate the average treatment on the treated.

Propensity score matching is a technique used for non-experimental data to identify a control group that exhibits the same distribution of covariates as the treatment group. In this paper, we use this method to identify a group of students in public schools and private voucher schools without tuition that display the same characteristics as the students that have a scholarship to attend private voucher schools. Propensity score matching is often used by statisticians and is becoming increasingly popular among economists as a method to measure the impact of training programs. The most common application of propensity score matching is to estimate the impact of job training programs (Heckman et al., 1997b; Dehejia and Wahba, 2001). This paper applies a similar methodology to estimate the impact of private school education on academic achievement.

There are three important assumptions that make propensity score matching a feasible model. The first is the statistical independence of (Y_0, Y_1) and D conditional on X :

$$\text{Assumption 1: } (Y_0, Y_1) \perp D \mid X$$

where Y_0 is the SIMCE score of a student in a public school or private voucher school without tuition, Y_1 is the SIMCE score of a student in a private school with tuition, D is the type of school the student attends, and X are the students' characteristics. This first assumption allows us to use the outcome of a public

school student with X characteristics as a proxy for $E(Y_0 | D=1, X)$. However, matching students based on X is a complex and difficult process given the high dimensionality of X . According to Rosenbaum and Rubin (1983), an alternative to matching based on X is to use the propensity score, which they define as "the conditional probability of assignment to a particular treatment given a vector of covariates." Rosenbaum and Rubin argue that if the matched observations have homogenous propensity scores, then they will also have the same distribution of X .

Let the propensity score be denoted by $P(x) = \Pr(D=1 | X)$. In situations in which $P(x)$ is not known (which is almost always the case for nonrandomized experiments), it can be estimated by models such as the probit or logit. Given that students face multiple school options, we calculate $P(x)$ using a multinomial logit model as in the estimates of the previous section.

The second assumption for propensity score matching is

$$\text{Assumption 2: } 0 < P(x) < 1$$

If $P(x)$ equals 1, then students with those characteristics always attend private school and therefore no match in a public school can be found. The same logic applies if $P(x)$ equals 0. As a result, the assumption that $P(x)$ lies between 0 and 1 is an important condition to guarantee that matches can be found for all students. Rosenbaum and Rubin refer to assumptions 1 and 2 together as a "strong ignorability" condition.

The propensity score is calculated on the basis of 29 observable variables, but we must also consider the unobservable characteristics that are typical of students in private schools. The third assumption states that the unobserved characteristics that are captured by the error term, U_0 , have the same distribution regardless of whether the student is in the treatment or control group.

$$\text{Assumption 3: } E(U_0 | D = 1, P(X)) = E(U_0 | D=0, P(X))$$

As emphasized by Heckman et al. (1997a), this assumption does not imply that $E(U_0 | P(X)) = 0$; rather, it assumes that the distribution of the unobservables is the same for the treatment and control groups. With these three assumptions in hand, we are now ready to calculate propensity scores for the students in this analysis.

The treatment group is composed of students in private voucher schools with tuition who receive scholarships that are between 50 and 100 percent of the tuition. As discussed earlier, we also control for the level of education of the parents by only including students whose parents have less than a university education in both the treatment and control groups.

As outlined by Dehajia and Wahba (2001), there are three main issues to be considered when implementing matching: 1) whether or not to match with replacement, 2) how many comparison units to match to each treated unit, and 3) which matching method to use.¹⁴ In this study, we will implement a range of estimators in order to gauge the effect of using a particular matching estimator on the outcome: the one-to-one estimator with replacement, the 5-nearest neighbor estimator with replacement, the kernel regression matching estimator, and local linear regression estimator. All four matching estimators were conducted using common support. After the matches are made, we use a difference in means test to estimate whether there exists a statistically significant difference in the academic achievement of the control groups compared to their match in the treatment group.

The results of the four matching estimators can be found in table 8, along with the average propensity score. All estimators reveal statistically significant differences in the language and science SIMCE scores of students in public schools compared to scholarship students in private voucher schools with tuition. The scores of scholarship students in private voucher schools are higher than those of students in public schools, with the estimated difference ranging from 6.775 to 9.204 points. These estimated differences are not large considering the average score on the language and science SIMCE is 255 and 254 points (respectively) with a respective standard deviation of 55 and 54 points. The estimated effect of 13 percent to 17 percent of one standard deviation is of the same order of magnitude as the estimated effect of vouchers in Colombia (Angrist et al., 2002).

The performance gap between scholarship students in private voucher schools with tuition compared to students in private voucher schools without tuition tended to be not significant, with the exception of local linear regression matching estimator, which found that students in private voucher schools with tuition either scoring higher than students in private voucher schools without tuition by 3.358 points. All other

¹⁴ Todd (1999), Leuven and Sianesi (2003), Dehajia and Wahba (2001) and Abadie et al. (2004) describe in further detail the different types of matching estimators that can be used and provide details on how to implement them.

matching estimators found differences that were not significant. One should also note that using a common support changed the composition of the treatment group for the two control groups by eliminating students who were outside of the designated range.

In summary, we have found that students that are randomly moved from public schools to private voucher schools score better in language and science standardized tests. The outcome differences, though statistically significant, are small, ranging from 13 percent to 17 percent of one standard deviation. The difference between private schools that charge tuition is usually not statistically significant.

d. Robustness checks

We next conduct a series of robustness checks to see the effect that changing our assumptions and models has on the results. The first robustness check is to match the scholarship students to non-scholarship students in private voucher schools with tuition (both with limited parental education) in order to check differences in their observed characteristics and test scores. Table 9 shows the results from this test. The differences in the language and science SIMCE scores of the treatment and control groups are not statistically significant, which indicates that scholarship and non-scholarship students are not performing differently. This finding supports the assumption that schools do not award scholarships based on academic achievement.

The second robustness check repeats the analysis conducted in the main study, but limits the parental education of the students included in the analysis from the first stage, instead of in the last stage. In other words, the only students included in the logit for the probability of receiving a scholarship, the multinomial logit for the probability of attending each school type, and the propensity score matching are those students whose parents' highest level of education is high school or less. The results of this analysis can be found in table 10.¹⁵ The results from the propensity score matching when conducting this robustness check confirms the results of the main analysis of the study: students in private voucher schools with tuition schools tend to outperform their counterparts in public schools by 8 to 21 points in the

¹⁵ For the sake of brevity, we only show the average treatment on the treated results. The logit and multinomial logit results do not change drastically from the main analysis. Again, we see that language and science SIMCE scores are not statistically significant in the probability of receiving a scholarship, indicating that scholarships are not awarded based on academic achievement. Characteristics that continue to be important in the awarding of scholarships are the student's family income and whether they attend a religious school. The multinomial logit shows nearly identical results as the main analysis, with the important variables that determine the school type of a student being income, the number of schools in the student's neighborhood, anticipated peer effects in the school, religious, academic prestige, teacher quality, and the school's values. Detailed results are available upon request.

language and science SIMCE. The differences were usually not significant for students in private voucher schools without tuition, with only the one-to-one estimator showing a slight positive difference in the science SIMCE and the local linear regression showing an even smaller positive difference in the language SIMCE. Once again, one should also note that using a common support changed the composition of the treatment group for the two control groups by eliminating students who were outside of the designated range.

The third and final robustness check entailed conducting the original analysis that included all students (regardless of their parental education), but use an alternate definition of a scholarship. In this test, a scholarship was defined as a reduction in the school tuition that was equivalent to five percent or more of the student's family income. The results can be found in tables 11 to 14. Once again, we find that the language SIMCE scores are not significant when calculating the probability of receiving a scholarship.¹⁶ Students with a lower income and have attended the school for more years are more likely to receive a scholarship; furthermore, students who are farther from the average income of the school, have more private schools (but fewer total number of schools) in their neighborhood, have less educated mothers and siblings, are older than their peers, and those whose school have more per pupil resources, is higher ranked and is religious are more likely to receive scholarships. The results of the multinomial logit are interesting because they indicate that after controlling for the other characteristics; income only influences the probability of attending a private voucher school with tuition. The only characteristics that are significant in increasing the probability of attending both types of private voucher schools are that the school is religious, there are a large number of private schools in the students' neighborhood, there are positive peer effects (as measured by the average education of the mothers in the school), and the parents chose the school for socio-cultural reasons or the school's values.

The results from the propensity score matching of the third robustness check are similar to the results found when using the original definition of a scholarship. The language and science SIMCE scores of students in public schools are lower than those of their counterparts in private voucher schools with tuition typically by 6.909 to 12.670 points. The difference in language SIMCE scores for students in private voucher schools with tuition compared to students in private voucher schools without tuition is usually not

¹⁶ The science SIMCE scores are statistically significant when data on all schools was used; however, this relationship was not significant in the top 10% of private voucher schools in Santiago. These results are unusual because one would expect the top 10% of private schools to be more selective with their scholarships than all private voucher schools together.

significant by any matching estimator, with the exception being the local linear regression which finds a positive difference of 2.798 in the language SIMCE. All other matching estimators find a difference that is not statistically significant.

Section VI: Conclusions

The results of our paper have shown that students in private voucher schools with tuition score higher than students in public schools, but only very slightly. All the robustness checks show that their scores are higher by approximately 8 points, which is approximately equal to 0.15 standard deviations. These findings are consistent with other studies that have also found test score gains due to vouchers of about 0.2 standard deviations (Angrist et al, 2002). The performance of students in private voucher schools with tuition compared to students in private voucher schools without tuition is typically not statistically significant, although in a few rare cases, students in private voucher schools appear to have very slightly higher scores than students in private voucher schools without tuition.

The slight difference in test scores between private voucher schools with tuition and public schools could potentially be attributed to a variety of reasons. The first may be that private voucher schools with tuition provide a better quality of education than public schools, perhaps because they run the schools under better management, they have access to more resources – a variable we accounted for in our school choice models-- or because market competition has forced private voucher schools with tuition to improve their quality of education in order to attract students. The latter hypothesis is supported by Gallego (2005) who presents evidence that greater competition increases test scores, particularly when the schools are subject to financial consequences. Another possible explanation for the difference in test scores is that there are positive peer effects that occur in private voucher schools with tuition – captured partially in our models by the mothers’ average education. Although the students in our analysis are typically from low-income families with low parental education, it is likely that their friends and classmates come from families that have higher incomes and more parental education. These positive peer effects could have an impact on the education of the scholarship students.

Regardless of what the specific factors cause the difference in test scores, the findings of this paper confirm that it is possible to create an environment in which the academic achievement of low-income

students can be improved. Disentangling exactly which factors contribute to a better education for low-income students is an important issue that should be carefully examined in future work.

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Table 1: Voucher Payments According to Tuition

Tuition paid by parents	Number of private voucher schools that charge this tuition in Santiago	Voucher reduction	Scholarship Fund*	
			State contribution (percentage of voucher reduction)	School contribution (percentage of tuition)
0 to 0.5 USE**	99	0 %	0%	5%
0.5 to 1 USE	238	10%	100%	5%
1 to 2 USE	187	20%	50%	7%
2 to 4 USE	127	35%	20%	10%

* The scholarship fund provides either full or partial scholarships to students in the school. The amount of money contributed by the state and the school depends on how much tuition is aid by parents – schools that charge a large tuition are required to contribute a larger percentage to the scholarship fund and receive a smaller percentage of the subsidy from the state.

** USE (Unidad de Subvención Escolar) is the monetary unit used for distributing the vouchers to schools. The USE is re-adjusted every year; in 2002, the value was 11,747 pesos (approximately \$22).

Source: Ministry of Education.

Table 2: Variables used in the analysis

Name of Variable	Description	Source
Student characteristics		
SIMCE math score	Student's score on the math section of the SIMCE	SIMCE database
SIMCE language score	Student's score on the language section of the SIMCE	SIMCE database
SIMCE science score	Student's score on the science section of the SIMCE	SIMCE database
# schools in student's neighborhood	Number of schools in the student's neighborhood of residence	Parental questionnaire
# private schools in student's neighborhood	Number of private schools in the student's neighborhood of residence	Parental questionnaire
Male	Dummy: 1 if the student is male, 0 if female	Parental questionnaire
Father's education	Number of years of education for the student's father	Parental questionnaire
Mother's education	Number of years of education for the student's mother	Parental questionnaire
Single mother's education	Interaction variable: Number of years of education for student's mother if she is single	Parental questionnaire
Siblings	Dummy: 1 if the student has siblings that attend the school, 0 if not.	Parental questionnaire
Single mother	Dummy: 1 if the student lives with the mother only, 0 if not	Parental questionnaire
Expectations: university	Dummy: 1 if the parents expect student to attend college, 0 if not	Parental questionnaire
Expectations: technical or professional institute	Dummy: 1 if the parents expect student to attend a technical or professional institute, 0 if not	Parental questionnaire
Income (divided by 100,000)	Family income divided by 100,000 pesos	Parental questionnaire
Distance from school's income	Difference between the student's income and the average income of the school	Parental questionnaire
Tuition paid by student	Monthly tuition paid by the student	Parental questionnaire
Scholarship	Dummy: 1 if the student has a school scholarship, 0 if not	Parental questionnaire ¹⁷
Repeated grade	Dummy: 1 if the student has repeated a grade, 0 if not	Parental questionnaire
Age if repeated	Age of the student if they have repeated a grade	Parental questionnaire
Difference from average age (10 years old)	Difference between the student's age and the average age of a student in 4 th grade (10 years old)	Parental questionnaire
Preschool	Dummy: 1 if the student attended preschool, 0 if not	Parental questionnaire
# years attended school	The number of years the student has attended the school	Parental questionnaire
Reason for school choice: proximity	Dummy: 1 if the student's primary reason for attending the school is proximity	Parental questionnaire
Reason for school choice: family members	Dummy: 1 if the student's primary reason for attending the school is other family members attended school	Parental questionnaire
Reason for school choice: academic prestige	Dummy: 1 if the student's primary reason for attending the school is for its academic prestige	Parental questionnaire
Reason for school choice: socio-cultural	Dummy: 1 if the student's primary reason for attending the school is for socio-economic reasons	Parental questionnaire
Reason for school choice: teacher quality	Dummy: 1 if the student's primary reason for attending the school is because of the quality of teachers	Parental questionnaire
Reason for school choice: values	Dummy: 1 if the student's primary reason for attending the school is because of the value-based teachings	Parental questionnaire
Reason for school choice: full day schedule	Dummy: 1 if the student's primary reason for attending the school is because it has a full day schedule (from 8 am to 4 pm)	Parental questionnaire
Reason for school choice: low cost	Dummy: 1 if the student's primary reason for attending the school is because of the low cost	Parental questionnaire
Reason for school choice: only option	Dummy: 1 if the student's primary reason for attending the school is because it was the only option	Parental questionnaire
School characteristics		
School type	School type (0 if public, 1 if private voucher with no tuition and 2 if private voucher with tuition)	SIMCE database
# of schools in school's neighborhood	Number of schools in the school's neighborhood	SIMCE database
# of private schools in school's neighborhood	Number of private schools in the school's neighborhood	SIMCE database
Monthly tuition	Monthly tuition of the school	Phone calls and parental questionnaire
Per pupil resources of the school	The amount spent per pupil (includes school and state resources)	Ministry of Education and the Sub-secretary of Regional Development
Average mothers' education in the school	Average number of years of education for the mothers of students in the school	Parental questionnaire
SD of school's income (heterogeneity)	Standard deviation of the students' income in the school	Parental questionnaire
Religious	Dummy: 1 if school is religious, 0 if not religious	Survey of principals (1999)
New school	Dummy: 1 if school did not exist in 2000, 0 if it did	Ministry of Education
School's rank in 2000	The school's rank among schools in terms of its average SIMCE score in 2000 (0 if school did not exist in 2000)	SIMCE database (2000)
School ranked in top 10% of private voucher schools in 2000	Dummy: 1 if school was in the top 10 percent of private voucher schools in 2000, 0 if not	SIMCE database

¹⁷ A student is considered to have a scholarship if they reported paying between 0 to 50 percent of the school's tuition.

Table 3: Summary statistics for the database¹⁸

Variable	Observations	Mean	SD	Min	Max
Student characteristics					
SIMCE math	87,339	250.8	53.9	94	379
SIMCE language	87,274	254.7	54.6	101	376
SIMCE science	87,397	253.9	53.6	94	386
# of schools in neighborhood of residence	88,079	52.6	32.1	4	125
# of private schools in neighborhood of residence	88,079	36.6	27.5	0	99
Male	93,719	0.5	0.5	0	1
Mother's education	88,638	11.2	3.4	1	22
Father's education	86,213	11.7	3.4	1	22
Single mother's education	87,001	2.4	4.9	0	22
Siblings	91,684	0.6	0.5	0	1
Single mother	91,684	0.2	0.4	0	1
Parents' educational expectations: university	91,076	0.5	0.5	0	1
Parents' educational expectations: technical or professional school	91,076	0.1	0.3	0	1
Income (divided by 100,000)	91,104	3.3	4.4	0.5	20
Distance from school's income	91,104	0.0	2.3	-18.9	18.5
Tuition paid by student	90,792	17,564	36,023	0	212,000
Scholarship (defined as 50% of tuition)	90,699	0.1	0.2	0	1
Scholarship (defined as 5% of income)	89,129	0.0	0.2	0	1
Repeated grade	91,892	0.1	0.3	0	1
Age if repeated a grade	90,809	0.8	2.8	0	14
Difference from average age (10 years old)	92,444	-0.4	0.7	-4	4
Preschool	91,465	0.5	0.5	0	1
# years attended school	89,273	4.0	1.6	1	6
Reason for school choice: proximity	81,503	0.4	0.5	0	1
Reason for school choice: family members	81,503	0.1	0.3	0	1
Reason for school choice: academic prestige	81,503	0.2	0.4	0	1
Reason for school choice: socio-cultural	81,503	0.0	0.2	0	1
Reason for school choice: teacher quality	81,503	0.1	0.3	0	1
Reason for school choice: values	81,503	0.1	0.3	0	1
Reason for school choice: full day schedule	81,503	0.0	0.1	0	1
Reason for school choice: low cost	81,503	0.0	0.2	0	1
Reason for school choice: only option	81,503	0.0	0.1	0	1
School characteristics					
# of schools in school's neighborhood	1,692	49.8	31.7	4	125
# of private schools in school's neighborhood	1,692	34.7	26.9	0	99
Monthly tuition of school	1,691	22,249	40,424	0	212,000
Per pupil resources	1,548	40,793	34,856	0	274,497
Average mothers' education in the school	1,690	11.2	2.4	5	17
SD of school's income (heterogeneity)	1,687	215,261	152,935	0	1,125,833
Religious	1,504	0.1	0.3	0	1
New school	1,692	0.1	0.3	0	1
School's rank in 2000	1,692	660	498	0	1,548
School ranked in top 10% of private voucher schools in 2000	617	0.1	0.3	0	1

¹⁸ Summary statistics are for students in Santiago who are between the ages of 6 and 14 and attend a public school, private voucher school without tuition or private voucher schools with tuition.

Table 4: Basic statistics by school type for 4th graders in 2002 (Santiago only)

Variable	Public	Private voucher		Private non- voucher
		No tuition	Tuition	
SIMCE math	233	237	258	299
SIMCE science	235	242	263	299
SIMCE language	236	241	263	301
Father's education	10.5	10.6	11.9	15.9
Mother's education	9.7	10.0	11.6	15.4
Family income	164,090	176,400	267,701	1,313,929
Tuition paid by student	0	0	13,346	107,996
% enrollment	39.5%	7.8%	41.8%	10.9%

Table 5: Estimation of the probability of receiving a scholarship to a private voucher school with tuition

Variable	
# schools in school's neighborhood	-0.005 (0.004)
# private schools in school's neighborhood	0.008 (0.005)
Male	-0.008 (0.041)
Father's education	0.005 (0.008)
Mother's education	-0.018 (0.009)
Single mother	-0.089 (0.200)
Single mother's education	0.020 (0.017)
Siblings	0.218 (0.042)**
Expectations - university	-0.020 (0.053)
Expectations - technical or professional institute	-0.132 (0.065)*
Income	-0.728 (0.060)**
Income squared	0.093 (0.007)**
Income cubed	-0.003 (0.000)**
Per pupil resources of the school	0.000 (0.000)
SD income	0.066 (0.049)
Distance from average income	0.182 (0.044)**
Repeated grade	2.428 (1.307)
Age if repeated	-0.219 (0.125)
Difference from average age	0.109 (0.039)**
Preschool	-0.086 (0.042)*
School's ranking in 2000	0.000 (0.000)**
New school	0.742 (0.440)
Religion	0.318 (0.055)**
# years attended school	0.079 (0.015)**
constant	-1.756 (0.177)**
observations	26,062

Standard errors are in parentheses.

* Significant at 5%; ** significant at 1%.

Table 6: Estimation of the probability of receiving a scholarship to each school type INCLUDING SIMCE SCORES

Variable	Language SIMCE		Science SIMCE	
	Private voucher with tuition	Private voucher with tuition in top 10%	Private voucher with tuition	Private voucher with tuition in top 10%
SIMCE score	0.001 (0.000)	-0.002 (0.002)	0.001 (0.000)	-0.001 (0.002)
# schools in school's neighborhood	-0.005 (0.004)	-0.048 (0.014)**	-0.005 (0.004)	-0.052 (0.014)**
# private schools in school's neighborhood	0.008 (0.005)	0.050 (0.017)**	0.008 (0.005)	0.054 (0.017)**
Male	-0.004 (0.043)	-0.023 (0.136)	-0.004 (0.043)	0.017 (0.137)
Father's education	0.009 (0.009)	-0.013 (0.029)	0.007 (0.009)	-0.014 (0.029)
Mother's education	-0.016 (0.010)	0.030 (0.034)	-0.017 (0.010)	0.025 (0.034)
Single mother	-0.038 (0.209)	-0.112 (0.897)	-0.110 (0.210)	-0.078 (0.892)
Single mother's education	0.017 (0.017)	0.011 (0.066)	0.023 (0.018)	0.011 (0.066)
Siblings	0.226 (0.044)**	0.140 (0.138)	0.233 (0.044)**	0.155 (0.139)
Expectations - university	-0.003 (0.055)	0.553 (0.261)*	0.009 (0.055)	0.552 (0.261)*
Expectations - technical or professional institute	-0.112 (0.068)	0.515 (0.303)	-0.120 (0.068)	0.518 (0.303)
Income	-0.775 (0.062)**	-1.409 (0.272)**	-0.781 (0.062)**	-1.422 (0.275)**
Income squared	0.096 (0.008)**	0.152 (0.051)**	0.095 (0.008)**	0.149 (0.052)**
Income cubed	-0.003 (0.000)**	-0.007 (0.003)*	-0.003 (0.000)**	-0.007 (0.003)*
Per pupil resources of the school	0.000 (0.000)	0.000 (0.000)**	0.000 (0.000)	0.000 (0.000)**
SD income	0.094 (0.051)	0.521 (0.213)*	0.104 (0.051)*	0.553 (0.215)*
Distance from average income	0.146 (0.046)**	-0.215 (0.162)	0.140 (0.046)**	-0.232 (0.163)
Repeated grade	2.434 (1.401)	4.978 (8.892)	3.294 (1.454)*	4.598 (8.761)
Age if repeated	-0.217 (0.134)	-0.404 (0.862)	-0.302 (0.139)*	-0.366 (0.849)
Difference from average age	0.115 (0.041)**	0.038 (0.132)	0.116 (0.041)**	0.006 (0.132)
Preschool	-0.079 (0.044)	-0.132 (0.149)	-0.084 (0.044)	-0.150 (0.149)
School's ranking in 2000	0.000 (0.000)**	0.000 (0.001)	0.000 (0.000)**	0.000 (0.001)
New school	0.890 (0.444)*		0.710 (0.468)	
Religion	0.300 (0.057)**	0.603 (0.144)**	0.305 (0.057)**	0.612 (0.145)**
# years attended school	0.102 (0.016)**	0.163 (0.059)**	0.101 (0.016)**	0.161 (0.060)**
constant	-2.075 (0.215)**	-3.220 (0.851)**	-2.135 (0.216)**	-3.455 (0.849)**
observations	24457	3062	24486	3060

Standard errors are in parentheses.

* Significant at 5%; ** significant at 1%.

Table 7: Estimation of the probability of attending each school type compared to public school

Variable	Private voucher without tuition	Private voucher with tuition
# schools in student's neighborhood	-0.041 (0.004)**	-0.004 (0.003)
# private schools in student's neighborhood	0.050 (0.004)**	0.014 (0.003)**
Probability of scholarship to a private voucher with tuition	-6.414 (0.706)**	-6.691 (0.528)**
Male	-0.011 (0.037)	0.053 (0.027)*
Father's education	-0.000 (0.007)	0.001 (0.005)
Mother's education	-0.012 (0.008)	-0.022 (0.006)**
Single mother	-0.125 (0.171)	-0.075 (0.131)
Single mother's education	0.013 (0.016)	0.011 (0.011)
Expectations - university	0.005 (0.047)	0.118 (0.034)**
Expectations - technical or professional institute	-0.096 (0.055)	-0.050 (0.041)
Income	-0.561 (0.086)**	-0.593 (0.060)**
Income squared	0.060 (0.012)**	0.066 (0.008)**
Income cubed	-0.002 (0.000)**	-0.002 (0.000)**
School per pupil resources	-0.000 (0.000)	0.000 (0.000)**
Mothers' education in the school	2.874 (0.183)**	5.706 (0.159)**
Mothers' education in the school squared	-0.139 (0.009)**	-0.225 (0.007)**
Repeated grade	0.721 (0.913)	2.083 (0.826)**
Age if repeated	-0.042 (0.086)	-0.175 (0.078)*
Difference from average age	0.097 (0.036)**	-0.017 (0.027)
Preschool	-0.033 (0.039)	-0.097 (0.028)**
Religion	7.410 (0.345)**	5.183 (0.341)**
Reason for choosing school: proximity	-0.038 (0.143)	-0.100 (0.095)
Reason for choosing school: family	0.417 (0.149)**	0.034 (0.100)
Reason for choosing school: academic prestige	0.608 (0.147)**	0.002 (0.099)
Reason for choosing school: socio-cultural	0.456 (0.189)*	0.506 (0.126)**
Reason for choosing school: teacher quality	0.544 (0.148)**	0.189 (0.099)
Reason for choosing school: values	1.426 (0.158)**	0.920 (0.113)**
Reason for choosing school: low cost	-0.054 (0.196)	-0.693 (0.131)**
Reason for choosing school: only option	0.187 (0.157)	-0.768 (0.110)**
constant	-14.653 (1.006)**	-37.914 (0.896)**
observations	46719	46719

Table 8: Matching results for scholarship students in private voucher schools with tuition

Sample		Matching estimator	Number of observations	Mean propensity score	Language SIMCE score	Science SIMCE score
Treatment group	Scholarship students in private voucher schools with tuition		1,189	0.651	261.582	261.349
					Language SIMCE treatment effect	Science SIMCE treatment effect
Matched comparison	Students in public schools	One-to-one replacement	1,189	0.651	6.916**	6.775**
		Nearest neighbor (5)	2,519	0.651	7.292**	8.849**
		Kernel	10,574	0.647	9.204**	9.178**
		Local Linear Regression	10,574	0.651	9.026**	8.753**

Sample		Matching estimator	Number of observations	Mean propensity score	Language SIMCE score	Science SIMCE score
Treatment group	Scholarship students in private voucher schools with tuition		1,179	0.648	261.333	261.161
					Language SIMCE treatment effect	Science SIMCE treatment effect
Matched comparison	Students in private voucher schools without tuition	One-to-one replacement	1,179	0.648	-1.036	1.720
		Nearest neighbor (5)	1,634	0.647	1.294	-0.155
		Kernel	2,402	0.642	0.990	1.814
		Local Linear Regression	2,402	0.648	3.358**	1.607

Table 9: Robustness check #1 - Matching results for scholarship versus non-scholarship students in private voucher schools with tuition

Sample		Matching estimator	Number of observations	Mean propensity score	Language SIMCE score	Science SIMCE score
Treatment group	Scholarship students in private voucher schools with tuition		1,267	0.672	262.341	262.278

Sample		Matching estimator	Number of observations	Mean propensity score	Language SIMCE Treatment effect	Science SIMCE Treatment effect
Matched comparison	Non-scholarship students in private voucher schools with tuition	One-to-one replacement	1,267	0.672	-0.598	0.073
		Nearest neighbor (5)	4,621	0.672	0.713	0.976
		Kernel	10,714	0.672	1.471	1.647
		Local Linear Regression	10,714	0.672	1.500	1.615

Table 10: Robustness check #2 - Matching results for scholarship students in private voucher schools with tuition USING STUDENTS WITH LOW PARENTAL EDUCATION

Sample		Matching estimator	Number of observations	Mean propensity score	Language SIMCE score	Science SIMCE score
Treatment group	Scholarship students in private voucher schools with tuition		1,214	0.663	261.535	261.456
					Language SIMCE treatment effect	Science SIMCE treatment effect
Matched comparison	Students in public schools	One-to-one replacement	1,214	0.663	14.745**	21.025**
		Nearest neighbor (5)	2,518	0.663	10.885**	14.100**
		Kernel	10,574	0.660	8.760**	9.048**
		Local Linear Regression	10,574	0.663	8.383**	8.537**

Sample		Matching estimator	Number of observations	Mean propensity score	Language SIMCE score	Science SIMCE score
Treatment group	Scholarship students in private voucher schools with tuition		1,168	0.650	261.109	261.015
					Language SIMCE treatment effect	Science SIMCE treatment effect
Matched comparison	Students in private voucher schools without tuition	One-to-one replacement	1,168	0.650	0.192	3.298*
		Nearest neighbor (5)	1,662	0.650	1.505	0.747
		Kernel	2,402	0.644	0.685	1.486
		Local Linear Regression	2,402	0.650	2.867*	1.432

Table 11: Robustness check #3 - Probability of a scholarship to a private voucher school with tuition USING ALTERNATE DEFINITION OF SCHOLARSHIP

Variable	
# schools in school's neighborhood	-0.013 (0.005)*
# private schools in school's neighborhood	0.020 (0.006)**
Male	0.053 (0.050)
Father's education	-0.008 (0.010)
Mother's education	-0.024 (0.011)*
Single mother	-0.246 (0.227)
Single mother's education	0.033 (0.019)
Siblings	0.215 (0.051)**
Expectations - university	0.054 (0.063)
Expectations - technical or professional institute	-0.077 (0.078)
Income	-1.415 (0.136)**
Income squared	0.231 (0.050)**
Income cubed	-0.012 (0.005)*
Per pupil resources of the school	0.000 (0.000)**
SD income	-0.204 (0.060)**
Distance from average income	0.807 (0.052)**
Repeated grade	1.949 (1.479)
Age if repeated	-0.168 (0.141)
Difference from average age	0.108 (0.048)*
Preschool	-0.069 (0.052)
School's ranking in 2000	0.000 (0.000)*
New school	1.207 (0.522)*
Religion	0.106 (0.069)
# years attended school	0.127 (0.018)**
constant	-2.465 (0.221)**
Observations	26114

Standard errors are in parentheses.

* Significant at 5%; ** significant at 1%.

Table 12: Robustness check #3 - Probability of a scholarship to each school type USING ALTERNATE DEFINITION OF SCHOLARSHIP AND INCLUDING SIMCE SCORES

Variable	Language SIMCE		Science SIMCE	
	Private voucher with tuition	Private voucher with tuition in top 10%	Private voucher with tuition	Private voucher with tuition in top 10%
SIMCE score	0.001 (0.001)	-0.002 (0.002)	0.001 (0.001)**	-0.000 (0.002)
# schools in school's neighborhood	-0.013 (0.005)*	-0.028 (0.015)	-0.012 (0.005)*	-0.027 (0.015)
# private schools in school's neighborhood	0.020 (0.006)**	0.024 (0.018)	0.019 (0.006)**	0.023 (0.018)
Male	0.062 (0.052)	0.147 (0.162)	0.046 (0.052)	0.178 (0.161)
Father's education	-0.003 (0.010)	-0.086 (0.035)*	-0.003 (0.010)	-0.082 (0.034)*
Mother's education	-0.022 (0.012)	0.008 (0.041)	-0.021 (0.012)	0.007 (0.041)
Single mother	-0.166 (0.237)	-0.127 (0.978)	-0.231 (0.239)	-0.051 (0.970)
Single mother's education	0.028 (0.020)	0.021 (0.073)	0.033 (0.020)	0.018 (0.073)
Siblings	0.202 (0.053)**	0.200 (0.164)	0.212 (0.053)**	0.219 (0.164)
Expectations - university	0.062 (0.065)	0.770 (0.296)**	0.062 (0.065)	0.767 (0.295)**
Expectations - technical or professional institute	-0.055 (0.081)	0.901 (0.340)**	-0.066 (0.081)	0.904 (0.340)**
Income	-1.560 (0.146)**	-1.495 (0.397)**	-1.566 (0.145)**	-1.507 (0.398)**
Income squared	0.273 (0.055)**	0.246 (0.112)*	0.272 (0.055)**	0.247 (0.112)*
Income cubed	-0.016 (0.006)**	-0.013 (0.010)	-0.015 (0.006)**	-0.013 (0.010)
Per pupil resources of the school	0.000 (0.000)**	0.000 (0.000)**	0.000 (0.000)**	0.000 (0.000)**
SD income	-0.184 (0.062)**	-0.233 (0.243)	-0.172 (0.062)**	-0.218 (0.244)
Distance from average income	0.775 (0.054)**	0.653 (0.160)**	0.766 (0.054)**	0.643 (0.159)**
Repeated grade	2.423 (1.608)	-0.127 (9.530)	3.561 (1.691)*	-0.579 (9.463)
Age if repeated	-0.212 (0.153)	0.102 (0.916)	-0.324 (0.162)*	0.151 (0.909)
Difference from average age	0.119 (0.050)*	0.177 (0.159)	0.123 (0.050)*	0.145 (0.158)
Preschool	-0.070 (0.054)	-0.084 (0.178)	-0.071 (0.054)	-0.111 (0.178)
School's ranking in 2000	0.000 (0.000)*	-0.000 (0.001)	0.000 (0.000)**	0.000 (0.001)
New school	1.473 (0.538)**		1.266 (0.557)*	
Religion	0.098 (0.072)	0.867 (0.174)**	0.098 (0.071)	0.877 (0.174)**
# years attended school	0.155 (0.020)**	0.290 (0.075)**	0.151 (0.019)**	0.295 (0.075)**
constant	-2.839 (0.269)**	-3.221 (1.006)**	-2.997 (0.269)**	-3.943 (0.995)**
observations	24507	3110	24535	3107

Standard errors are in parentheses.

* Significant at 5%; ** significant at 1%.

Table 13: Robustness Check #3 - Estimation of the probability of attending each school type compared to public school USING ALTERNATE DEFINITION OF SCHOLARSHIP

Variable	Private voucher without tuition	Private voucher with tuition
# schools in student's neighborhood	-0.037 (0.004)**	-0.001 (0.003)
# private schools in student's neighborhood	0.045 (0.004)**	0.010 (0.003)**
Probability of scholarship to a private voucher with tuition	-0.834 (0.397)*	-1.237 (0.264)**
Male	-0.005 (0.037)	0.059 (0.027)*
Father's education	-0.004 (0.007)	-0.003 (0.005)
Mother's education	-0.002 (0.008)	-0.013 (0.006)*
Single mother	-0.127 (0.170)	-0.089 (0.130)
Single mother's education	0.006 (0.015)	0.005 (0.011)
Expectations - university	0.026 (0.047)	0.145 (0.034)**
Expectations - technical or professional institute	0.001 (0.054)	0.049 (0.040)
Income	-0.025 (0.073)	-0.123 (0.050)**
Income squared	-0.003 (0.011)	0.012 (0.007)
Income cubed	0.000 (0.000)	0.000 (0.000)
School per pupil resources	0.000 (0.000)	0.000 (0.000)**
Mothers' education in the school	3.123 (0.182)**	6.010 (0.157)**
Mothers' education in the school squared	-0.152 (0.009)**	-0.240 (0.007)**
Repeated grade	-1.262 (0.883)	0.189 (0.805)
Age if repeated	0.138 (0.083)	-0.003 (0.076)
Difference from average age	0.025 (0.035)	-0.085 (0.026)**
Preschool	0.021 (0.038)	-0.044 (0.028)
Religion	7.125 (0.340)**	4.893 (0.337)**
Reason for choosing school: proximity	-0.072 (0.142)	-0.131 (0.095)
Reason for choosing school: family	0.356 (0.149)*	-0.023 (0.100)
Reason for choosing school: academic prestige	0.593 (0.147)**	-0.013 (0.099)
Reason for choosing school: socio-cultural	0.416 (0.188)*	0.469 (0.126)**
Reason for choosing school: teacher quality	0.512 (0.148)**	0.158 (0.099)
Reason for choosing school: values	1.388 (0.158)**	0.884 (0.112)**
Reason for choosing school: full day schedule	-0.054 (0.196)	-0.696 (0.131)**
Reason for choosing school: low cost	0.160 (0.157)	-0.793 (0.110)**
constant	-17.442 (0.959)**	-40.965 (0.864)**
observations	46719	46719

Table 14: Robustness check #3 - Matching results for scholarship students in private voucher schools with tuition USING ALTERNATE DEFINITION OF SCHOLARSHIP

Sample		Matching estimator	Number of observations	Mean propensity score	Language SIMCE score	Science SIMCE score
Treatment group	Scholarship students in private voucher schools with tuition		901	0.707	262.519	262.806
					Language SIMCE treatment effect	Science SIMCE treatment effect
Matched comparison	Students in public schools	One-to-one replacement	901	0.707	6.909**	12.670**
		Nearest neighbor (5)	1,771	0.707	10.257**	12.480**
		Kernel	10,574	0.704	8.984**	9.213**
		Local Linear Regression	10,574	0.707	8.659**	8.575**

Sample		Matching estimator	Number of observations	Mean propensity score	Language SIMCE score	Science SIMCE score
Treatment group	Scholarship students in private voucher schools with tuition		883	0.701	262.177	262.669
					Language SIMCE treatment effect	Science SIMCE treatment effect
Matched comparison	Students in private voucher schools without tuition	One-to-one replacement	883	0.701	2.614	2.703
		Nearest neighbor (5)	1,353	0.701	2.178	0.292
		Kernel	2,402	0.694	0.021	1.083
		Local Linear Regression	2,402	0.701	2.798*	0.800

